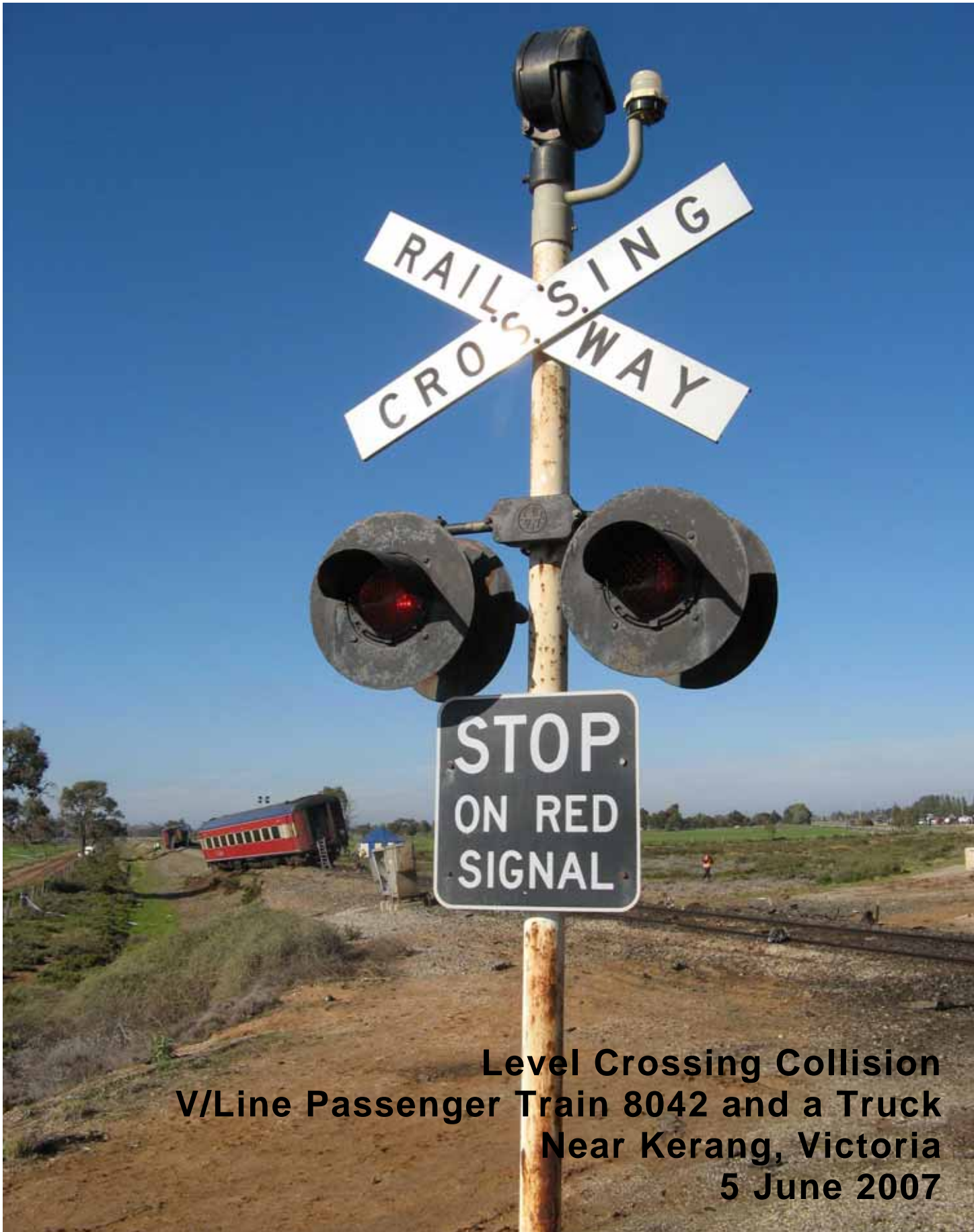




Office of the Chief Investigator  
Transport and Marine Safety Investigations

Rail Safety Investigation  
Report No 2007 / 09



**Level Crossing Collision  
V/Line Passenger Train 8042 and a Truck  
Near Kerang, Victoria  
5 June 2007**

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## THE CHIEF INVESTIGATOR

The Chief Investigator, Transport and Marine Safety Investigations is a statutory position established on 1 August 2006 under Part V of the *Transport Act 1983*.

The objective of the position is to improve public transport and marine safety by independently investigating public transport and marine safety matters.

The primary focus of an investigation is to determine what factors caused the incident, rather than apportion blame for the incident, and to identify issues that may require review, monitoring or further consideration. In conducting investigations, the Chief Investigator will apply the principles of 'just culture' and use a methodology based on systemic investigation models.

The Chief Investigator is required to report the results of investigations to the Minister for Public Transport and / or the Minister for Roads and Ports. However, before submitting the results of an investigation to the Minister, the Chief Investigator must consult in accordance with section 85A of the *Transport Act 1983*.

The Chief Investigator is not subject to the direction or control of the Minister(s) in performing or exercising his or her functions or powers, but the Minister may direct the Chief Investigator to investigate a public transport safety matter or a marine safety matter.

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## 1. EXECUTIVE SUMMARY

At 1334<sup>1</sup> on Tuesday 5 June 2007 V/Line passenger train 8042 was struck by a loaded articulated vehicle at a level crossing on the Murray Valley Highway about six road kilometres north-west of Kerang. The train was operating the 1300 service from Swan Hill to Melbourne and the semi-trailer was on a regular freight run from Wangaratta, Victoria to Adelaide, South Australia.

At the time of the incident the level crossing flashing lights and warning bells were operating.

The semi-trailer collided with the second passenger car of the locomotive-hauled three passenger car train. As a result, a large section of the body-side was torn away by the truck trailer and several seats on the right side (A side) of the car were torn from their mountings. The trailing bogie of the car was derailed. The truck trailer then struck the front right corner of the third car breaching the occupied area. The draft yoke connecting the second and third cars fractured and the third car derailed both bogies.

Eleven train passengers received fatal injuries and a further 14 and the truck driver were injured.

The incident was reported by the train driver and others at the scene and the emergency service unit arrived on site at 1350.

The Murray Valley Highway was opened to normal road traffic on 8 June 2007 and the rail line was re-opened on 12 June 2007.

The investigation determined that prior to the incident the train was serviceable and neither it nor the train crew had any causal role in the incident. Likewise, the truck was reported to be in good condition and well maintained. The rail and road infrastructure at the crossing were in good condition and the level crossing warning devices were also serviceable. Some minor variations from the relevant Australian Standard were later identified with the level crossing warning devices and signage but these were not a factor in the incident.

The truck driver refused to be interviewed by or provide any information to investigators. As a result the investigation was unable to determine the reason/s the truck driver did not heed the level crossing warning devices.

Following the incident the Victorian Government announced a package of safety improvements for a number of level crossings in the State.

The investigation recommends the following safety actions:

- A review by the train operator of a number of its operational procedures.
- A review by the train operator of rail passenger seating design and window treatments.
- Re-consideration of the speed limit for road vehicles at crossings and the reassessment and education of heavy road vehicle drivers.
- A review by the Department of Infrastructure of current crashworthiness standards applied to passenger-carrying rolling stock.

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<sup>1</sup> All times are Australian Eastern Standard Time.

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## 2. CIRCUMSTANCES

On Tuesday 5 June 2007 V/Line passenger train 8042, the 1300 service from Swan Hill to Melbourne, departed on schedule with planned stops at Kerang, Pyramid, Dingee, Eaglehawk and Bendigo. The train proceeded towards the first stop at Kerang and passed over 26 level crossings before approaching the crossing over the Murray Valley Highway, situated about six road kilometres north-west of the town. The train consisted of an N Class locomotive and three passenger cars.

At about 1030 on the same day a truck departed its depot in Wangaratta, Victoria to conduct a regular weekly freight run to Adelaide, South Australia. After travelling to Kerang the truck proceeded towards Swan Hill along the Murray Valley Highway.

About 25 seconds before reaching the level crossing over the Murray Valley Highway the train passed over the track circuit which activated level crossing flashing lights and warning bells. A short time later, as the train approached the 'whistle' board, the locomotive driver gave a short blast of the air horn. Then, about 11 seconds later and about 140 metres prior to the crossing, he sounded the horn for seven seconds prior to entering the crossing.

At 1334, as the train crossed the highway, the truck collided with it. The impact caused the side of the second car and the front right side of the third car to be torn open. The second car derailed but remained attached to the train. The locomotive and the two cars came to rest about 287 metres beyond the crossing. During the collision sequence a part of the draw-gear connecting the third car to the second car fractured. The third car became detached from the other vehicles and derailed before coming to rest with the leading end about 95 metres from the level crossing.

Eleven passengers on the train received fatal injuries and a further fourteen passengers and the truck driver were reported injured.

The second and third cars of the train were substantially damaged but the locomotive and first car were undamaged. The truck was substantially damaged.

Emergency services were alerted by the train crew, passengers and witnesses and the first ambulance arrived on site at 1350.

The Murray Valley Highway was opened to normal road traffic on 8 June 2007, after the removal of the truck and the derailed rolling-stock and the repair of the level crossing. The rail line was re-opened on 12 June 2007 following the repair of the track and level crossing protection equipment.

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## **3. FACTUAL INFORMATION**

### **3.1 Personnel information**

#### **3.1.1 Train crew - driver**

The N Class locomotive hauling this passenger train was crewed by one driver. The driver's cabin is situated at the front of the locomotive and cannot be accessed by other train crew or passengers while the train is in motion.

The driver of Train 8042 was qualified as a locomotive driver on the N Class locomotive and had operated this type of locomotive since they were first introduced into service in Victoria in the 1980s. He was assigned to the operator's Southern Cross driver's depot in Melbourne and was qualified to operate all trains to all areas of the state serviced from this depot. He worked a seven-hour shift on 4 June 2007 and was off duty on the two previous days. His medical certificate was current and unrestricted.

The driver last completed a practical assessment on the Bendigo to Swan Hill line on 5 December 2006. Since that time he has operated regularly over the route.

The driver last completed first aid training to Level One in March 2001.

#### **Locomotive driver interview**

At interview the driver advised that the service from Swan Hill operated normally and to schedule prior to the incident. He said that as his train approached the Murray Valley Highway level crossing he observed a van and a truck on the highway to his left, travelling towards Kerang. He then observed to his right, at a distance which he estimated to be 500 metres from the crossing, a white truck (the incident vehicle) travelling in a northerly direction. He reported that due to the distance from the crossing he did not see this vehicle as a threat to his train and turned his attention to the vehicles on his left travelling in a southerly direction. He observed the van pass over the crossing and then the flashing lights commence operation and noticed that the truck on his left was still about 200-300 metres from the crossing and slowing.

The train driver said he sounded the horn at or about the 'whistle' board and then just prior to the crossing he looked to his right and observed the white truck (the incident vehicle) at an estimated distance of 70-100 metres from the crossing. He reported sounding the horn but did not think the truck driver reacted. The locomotive had entered the crossing and he observed the truck driver turn the steering wheel to the left and appear to move upright and forward from his seat.

The driver said that he believed that the truck was going to miss the locomotive and did not apply the brakes as he thought that there was a chance that the truck might completely miss the train. On feeling the impact he applied the train brakes. He was aware that the train had derailed. The train commenced to slow and came to a stop after what he considered to be a relatively short distance. He commented that he was not aware of the magnitude of the incident until after the train had stopped and he went back to assist.

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The driver advised that there had been no other vehicles in front of the white truck but there were two vehicles behind it. The only other vehicles that he observed prior to the incident were the van and truck that had been on his left.

After the incident the driver said he contacted Train Control, by initially placing a standard call on the train radio and then almost immediately pressed the emergency call button. However, he does not recall what he told the train controller. He then called '000' on his mobile phone and asked to be put through to 'all services'. The call was transferred to another operator and he again asked for all services and gave his location. He later became aware that train control had attempted to contact him again but he did not receive the call which he put down to his private mobile phone, to which he had diverted his work mobile, being out of range.

He reported receiving a call from the operating conductor on the train end-to-end radio. He was aware that the conductor had tried to make a public announcement to the passengers but this was unsuccessful as electrical power had been lost in the incident.

The driver then went back along the train and provided what assistance he could to the conductors and passengers and to emergency services after they arrived. He commented that there was only one fatality in the third car and that he concentrated his efforts on the second car. He advised that he retrieved the first aid kit from the locomotive. He said that the first emergency service on site was the ambulance, which he thought arrived about 10 minutes after the incident.

The driver said that he remained at the incident site for about two hours. He reported that he did not receive any injuries as a result of the incident.

The driver was asked to comment on any aspects of the system that could be improved for the future. He commented that he thought that it would have been useful if first aid kits in the passenger cars contained pressure bandages. He said that drivers were not issued with a key to unlock the emergency egress ladder from its position in the first passenger car and that he was unsure how to connect it to the train, as drivers do not receive training on this task. However, he was eventually able to work out how to unlock the ladder and connect it and assist to evacuate the injured.

Asked about the general scene after the collision he commented that when he got to the cars he noticed all the passengers were covered in dust. Also, there was a lot of luggage lying around of which a considerable amount had been split open. He said that the right side of the second car had been pushed back into the rear of the car and that there were a number of bodies in that area. The left side of the car was substantially intact with most of the seats in position. However, there was debris throughout the car.

### **3.1.2 Train crew – conductors**

This service operated with a buffet car and was crewed by two conductors. One conductor was responsible for passenger safety and general customer services duties associated with the operation of the train while the second conductor was responsible solely for the operation of the buffet.



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## **Operating conductor**

The operating conductor joined V/Line Passenger Pty Ltd as a conductor in November 2005. He was assigned to the Bendigo depot and operated regularly on the line between Swan Hill and Kerang. On the day prior to the incident he commenced duty in Bendigo at 1407 and carried out conductor duties on a service to Melbourne. He then returned to Bendigo and crewed the 2024 service to Swan Hill, arriving there about 2230. He rested in Swan Hill that night, before commencing duty as the conductor on the 1300 service from Swan Hill to Melbourne.

The operating conductor was appropriately qualified to carry out conductor duties for the operator. He last completed Level Two first aid training in December 2005.

The operating conductor reported that the journey from Swan Hill had been normal and that at the time of the incident he was seated at the conductor station at the front of the first passenger car completing paperwork. He felt a jolt and was thrown around in his seat. He stood up, noticed that the air was full of dust and made a PA announcement to advise passengers to remain calm. He then commenced checking on the passengers in the first car and was advised that a truck had struck the train. After contacting the train driver he entered the second car and provided assistance to the occupants.

The operating conductor continued to assist and after about two hours he travelled with some passenger into Kerang and subsequently travelled with them back to Bendigo. He reported that he received some minor scratches and bruising as a result of the incident.

## **Buffet conductor**

The buffet conductor joined the operator as a conductor in January 2005. She was assigned to the Southern Cross depot in Melbourne. On the day prior to the incident she signed on at Melbourne at 1200 and operated the buffet service on the afternoon train to Swan Hill. She rested overnight in Swan Hill before commencing work to crew the buffet on the 1300 service to Melbourne.

The buffet conductor was qualified to carry out both operating and buffet conductor duties for the operator. She last completed Level Two first aid training in February 2005.

At the time of the incident she was in the buffet located in the forward section of car two. She reported that she heard a loud bang and was thrown against a refrigerator then to the floor. She attempted to hold on and noticed that the car was rocking around and was filling with dust which made it hard for her to breathe. When the motion stopped she attempted to locate her mobile phone but was not able to do so because of the debris in the buffet. She then went to check on the passengers in the second car. A short time later she used the other conductor's mobile phone to call the operator's office in Melbourne. She reported that a number of the passengers had received cuts and had pieces of glass from the shattered windows of the rail car embedded in their faces.

The buffet conductor said that she remained at the site assisting passengers for about two hours. She was not physically injured apart from bumping her head during the incident.

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### **3.1.3 Train passengers**

The train carried 34 passengers. The location of each passenger in the train prior to the incident was determined by use of the conductor's manifest and information supplied by the passengers and the conductors.

It was determined that prior to the collision six passengers were located in the first car (ACN21), 21 in the second car (BRN20), and seven in the third car (BN19).

Twenty five passengers received injuries, of which 11 were fatal.

### **3.1.4 Truck driver**

The driver of the truck had been employed continuously by the carrying company involved since his arrival in Australia in 1984. At the time of the incident the driver was 49 years old. He obtained his Victorian heavy vehicle drivers licence on his arrival in Australia. The licence was appropriate for the operation of the vehicle on the route taken. The driver also held a truck driver licence in The Netherlands for about three to four years prior to coming to Australia.

Information obtained by the investigation indicated that the truck driver had a good truck driving record. He has been checked on two recent occasions by vehicle inspectors. He did not have any infringements recorded as a result of those inspections.

The driver has driven this same route (Wangaratta to Adelaide) for the carrying company for the last seven years, averaging about one trip a week. His schedule was reported to have been regular, departing Wangaratta at about 1000 the same day of each week. On the day of the incident the driver departed the Wangaratta depot between 1030 and 1035, the delay due to late loading of freight from a consignee. The route taken by the driver is unknown but it was reported that the time to travel between Wangaratta and the level crossing via the most likely route is about three hours.

The trip on 5 June 2007 was his first after returning to work from four weeks leave.

The truck driver declined to be interviewed by the investigation or to supply a copy of the statement he gave to police following the incident. However, informal advice received from police indicates that on the evening of the incident the driver commented that as he approached the level crossing he first observed the vehicles stopped on the opposite side of the crossing. He then observed the crossing flashing lights and momentarily 'wondered' why the vehicles were stopped before seeing the train. The police also advised that the driver had reported that he had not been distracted by anything either inside or outside of his vehicle immediately prior to the crossing.

The truck driver received serious injuries and was taken to hospital in Melbourne.

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## **3.2 Rail vehicle**

### **3.2.1 General description**

The train consisted of a locomotive hauling a three-car passenger set, identified as car set number N7. The train had a total length of 88.4 metres and a total weight of 254 tonnes.

The locomotive was an N Class, number N460. This is a diesel-electric type locomotive with a mass of 124 tonnes, a total length of 20 metres, and a power rating of 1846 kW. It is fitted with an auxiliary generator to provide power to passenger cars. The locomotive was manufactured by Clyde Engineering Pty Ltd, along with a group of similar locomotives, between 1985 and 1987. It has a maximum allowable service speed of 115 km/h and is equipped with headlights, marker lights, ditch lights and main and low-note air horns. This type of locomotive is used extensively on the V/Line's network throughout Victoria.

Car set number N7 comprised passenger cars ACN21, BRN20 and BN19 with the No.1 (East) end leading in each case. Each car had a length of 22.8 metres and was manufactured at the Newport Workshops in Melbourne along with other N Class rail cars between 1981 and 1983.

First class car ACN21 was positioned directly behind the locomotive. It had seating for 52 passengers with a separate luggage storage area and conductor's workstation at the front of the car. The car had a mass of 43 tonnes.

Economy class car BRN20 was positioned directly behind ACN21. It had seating for 66 passengers and incorporated a buffet which was situated at the front (East) end. The car had a mass of 44 tonnes.

BN19 was positioned directly behind BRN20 and was the last car in the train. The car was an economy class car with seating for 88 passengers. It had a mass of 43 tonnes.

### **3.2.2 Train serviceability**

In accordance with company operating procedures the train was examined and certified fit for service prior to departure from Southern Cross Station for the outbound journey to Swan Hill.

Post incident, a number of checks were undertaken to assess the serviceability of key features of the vehicles at the time of the incident.

#### **Locomotive**

A review of maintenance records and an inspection of the locomotive did not reveal any pre-existing fault or irregularity which may have contributed to the collision.

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## Brakes, bogies and wheels

Post-incident testing found that the locomotive brakes were functional. Inspections similarly found that the condition of brake blocks and the state of brake rigging adjustment on the locomotive at the time of the incident was generally satisfactory<sup>2</sup>. Bogie inspection found that suspension components were in a satisfactory condition. Similarly, axle box clearances were found to be within tolerance and wheel diameter variation within service limits.

## Speedometer calibration

The diameter of the wheel adjacent to the speedometer drive was found to be approximately 984.5 metres which is 2.3 per cent greater than the 962 mm that was programmed into the speedometer unit. As a consequence, the speedometer would have provided an indicated speed slightly below the actual speed of the train. For example at an indicated speed of 100 km/h, the actual speed of the train would have been expected to be approximately 102 km/h.

## Lights

Locomotive head lights, ditch lights and marker lights were tested following the incident and all were found to be functional.

## Horn acoustic measurement

The N Class locomotive is equipped with a roof-mounted multi-chime main horn and an underfloor-mounted single-chime low-note horn. The main horn is typically used when the locomotive is moving, including as a warning device on the approach to a level crossing. The low-note horn is used when the volume of the main horn is not required, or may be objectionably loud, such as around workshops.

A horn sound level test was conducted in accordance with the requirements of Section 13.4 of the Railways of Australia (ROA) Manual. The main horn was found to comply with the ROA requirements, exceeding the minimum requirement by a significant margin. Whilst not relevant to this incident, the low-note horn was found to have a noise level significantly below the target range of 85-90 dB(A), as shown below.

Equipment Tested	Distance from horn	Average Reading dB(A)	ROA Requirement dB(A)	Pass / Fail
Main Horn	200 metres	98.4	Minimum of 88	Pass
Low-note Horn	100 metres	77.9	In range 85-90	Fail

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<sup>2</sup> The brake cylinder stroke of two wheels was found to be below the target range for the N class locomotive. This variation is not expected to have had any measurable effect on the retardation rate of the train.

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## **Passenger cars**

A review of maintenance records and inspection of the three passenger cars did not reveal any pre-existing fault or irregularity which may have contributed to the collision.

## **Brakes, bogies and wheels**

Post-incident testing and inspection of passenger car braking systems did not identify any fault in brake systems. The functioning of the automatic air brake of ACN21 was tested using cab No.1 of locomotive N460 to charge and apply the brakes and the system was found to be serviceable. Due to the damage to cars BRN20 and BN19, assessment of the braking system was limited to the brake blocks and the brake valves. The brake blocks were found to be serviceable and the brake valves were found to be within their test date.

A bogie inspection found that suspension components on ACN21 were in a satisfactory state of adjustment and condition. Similarly, axle box clearances on ACN21 were found to be within tolerance and wheel diameter variation within service limits. Due to the damage to passenger cars BRN20 and BN19, detailed assessment of bogie operating tolerances was not conducted.

## **Pre-existing structural condition**

Post-incident inspection of cars BRN20 and BN19 did not reveal any significant pre-existing structural fault or irregularity related to maintenance or workmanship. The pre-existing structural condition of the passenger cars was assessed as being very good for vehicles of their age. Overall, the level of corrosion was considered low by world standards for vehicles of their age. Minor pre-existing corrosion was identified around the door portals and similarly only minor visible corrosion (bubbling) was found around window apertures. No underframe corrosion of significance was identified.

### **3.2.3 N Class passenger train accident history**

Information provided by accredited rail organisations to the rail safety regulator, Public Transport Safety Victoria (PTSV), does not, in all cases, specify the type of locomotive involved in an incident. However, an analysis of information from PTSV indicates that for the period from January 2001 until September 2007 N Class locomotive hauled passenger trains have been involved in 15 level crossing collisions with motor vehicles (including this incident). Of these, five events have involved fatal injuries, with this event the only involving fatal injuries to train occupants.

Nine of the events occurred at level crossings that were provided with passive protection (Stop or Give Way signs) and six at crossings with active protection (flashing lights and bells). Two of the active crossings were fitted with boom barriers.

### **3.2.4 Event recorder information**

Locomotive N460 was equipped with a Fischer Mk 2 event recorder, which records a number of parameters associated with the performance and operation of the locomotive. These parameters include time, speed, air brake pressures, dynamic braking, crew alerter operation and air horn operation; however the operation of both head and ditch lights is not recorded.

A review of the recorded data found that the train departed Swan Hill at 1300:29. At 1333:52, when the locomotive was about 450 metres from the level crossing and travelling at a recorded speed of 92 km/h, the main horn was sounded for 0.35 seconds. Then at 1334:04 the main horn was again sounded when the locomotive was about 140 metres from the level crossing for 7.11 seconds until about the time of impact at 1334:11. The speed of the locomotive at the time of impact was recorded as 91 km/h.

Less than a second after impact a simultaneous reduction in brake pipe pressure and main reservoir pressure commenced, indicating a disruption of the brake air lines. This reduction continued for four seconds during which the locomotive travelled 89 metres. The brake pipe pressure reduction then increased to the emergency rate while the main reservoir pressure commenced to increase, indicating the application of emergency braking by the driver. At about the same time, the throttle setting was reduced from notch 2 probably to Idle, although the event recorder does not make this explicitly obvious. The train deceleration then increased to an average rate of  $1.7 \text{ m/s}^2$  for 12.3 seconds before the locomotive came to a stop after travelling 133 metres beyond the point of emergency brake application.

The normal stopping distance after the application of the emergency brakes of a similar train that was not derailed and travelling at the same speed as the incident train would be about 350 metres. See Appendix 1 for event recorder information.

### 3.3 Road vehicle

#### 3.3.1 General description

The truck involved was an articulated vehicle consisting of a prime mover and trailer (semi-trailer Figure 1).

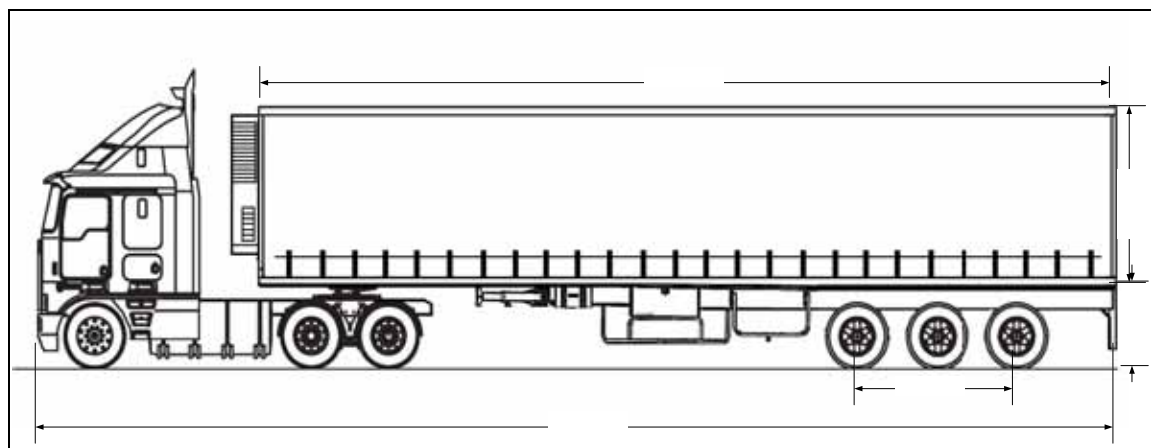


Figure 1. Schematic of truck

#### 3.3.2 Prime mover

The prime mover was a cab-over type Kenworth model K104 Aerodyne manufactured by Kenworth Trucks in Victoria and delivered to the carrying company in March 1999. The vehicle was certified to Australian Design Rules (ADR) 64 for road train and / or B-Double prime mover use with a gross vehicle mass of 24,100 kg and a gross combination mass of 70,000 kg. The vehicle was given an Application

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Approval for 62,500 kg. The tare mass of the prime mover was 8.9 tonnes including the mass of the driver and 150 litres of fuel.

The vehicle was powered by a Detroit Diesel Series 60-430 Cruise Power 430/500 engine with a maximum power rating of 373 kW.

The maximum geared speed of the vehicle was 127 km/h and it was electronically road-speed limited to 100 km/h by the engine electronic control unit (ECU) which limited the engine to 2,200 revolutions per minute.

At the time of manufacture, the prime mover complied with all applicable ADR criteria and was fitted with an approved ADR compliance plate in accordance with ADR 61.

The single-piece curved windscreen was manufactured to comply with ADR 8 with tinted interlayer in laminated safety glass and a minimum transmissibility of 75 per cent.

### **Maintenance**

The maintenance manual is customised for each individual truck by the manufacturer depending on the choice of options on the truck.

An inspection of the prime mover after the incident by police investigators found it to have been well maintained and in good condition with all scheduled servicing having been completed.

The prime mover manufacturer advised that data recorded by the engine management system was not available because in this installation it is lost when electrical (battery) power is lost.

### **3.3.3 Trailer**

The trailer was a 13.57 metres long insulated Kurtainer manufactured by Krueger Transport Equipment Pty Ltd. These trailers have a tare mass of 9200 kg, capacity of 93 cubic metres and a capability to carry 22 pallets. The trailer wheels are of the tri-axle configuration, with the third axle, and hence the rear-most wheels, being 15.67 metres from the front of the prime mover (Figure 2).

The trailer was equipped with a Carrier Ultra XL refrigeration unit, mounted on the forward end. The refrigeration unit delivers chilled air through an opening in the top of the trailer and the air is returned via an opening below the supply air opening. The unit compressor is located in the lower section of the refrigeration unit.

At the time of the incident the load on the trailer was 16.5 tonnes consisting of 14.5 tonnes of medium density fibreboard (MDF) sheets and 2.0 tonnes of miscellaneous freight.

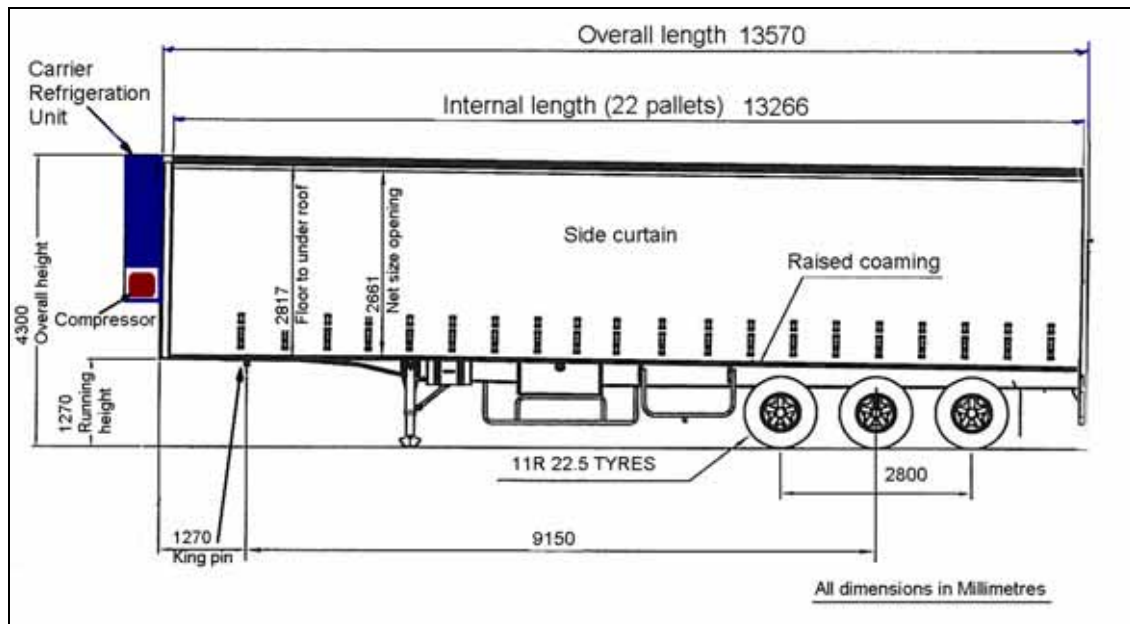


Figure 2. Krueger Kurtainer trailer

## Design & construction

The main floor of this model of trailer is constructed from 3 mm steel chequer plate, longitudinally supported by two main rail assemblies and 13.3 metre length pressed coamings on the sides. Transverse stiffening is provided by evenly spaced 2.5 metre rolled steel joist (RSJ) sections and 2.5 metre rectangular hollow section (RHS) sections at the forward and rear ends.

### 3.3.4 Truck braking system

The Kenworth-designed prime mover pneumatic braking system uses components supplied by a number of suppliers and is fitted with an anti-lock braking system (ABS). The braking system complied with ADR 35. The trailer braking system is not equipped with ABS.

The truck brakes are applied by the driver pushing down on the brake pedal. The system is such that the brakes are applied on the prime mover prior to the trailer, to help maintain directional control of the trailer.

### 3.3.5 Truck impact data

Figure 3 details the final path of the truck prior to collision and coming to rest. The skid marks on the road indicate heavy braking of the truck prior to the collision. The marks commenced approximately 49 metres prior to the rail track and veered to the left off the bitumen road surface onto the loose road surface and aligned with the trailer wheels at the truck's resting position. The skid marks are considered to have come from the locking of the trailer wheels, with the prime mover braking continuing to be effective under ABS action.

Due to the unavailability of recorded data from the truck, it is not possible to know with certainty at which point braking was initiated. What is known is that braking was initiated before the commencement of the skid marks and the driver was near upright as he attempted to brake heavily and avoid a collision. For the purposes of



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estimating the potential truck speed at impact, the investigation calculated two scenarios, one with braking becoming effective 10 metres prior to the commencement of the start of the skid marks and a second at 15 metres. These scenarios relate to the front of the truck being approximately 45 and 50 metres, respectively, from the crossing at the time the brakes became effective.

To assist in predicting potential braking performance and steering characteristics, the investigation conducted a trial using a similar truck with a fully laden trailer (about 9.5 tonnes heavier than the incident truck). The trial vehicle was capable of being brought to a stop from a speed of 100 km/h in a distance of 93 metres. The steering of the truck during the trial did not highlight any abnormal characteristics.

Using the average deceleration rate achieved in the trial, an estimated initial truck speed of 100 km/h and brake initiation when the front of the truck was 45 metres and 50 metres from the crossing, the investigation calculated a speed at impact of 65 km/h and 60 km/h respectively. For other parts of the investigation, a nominal truck impact speed of 60 km/h has been assumed notwithstanding potential variation in the braking initiation point and actual truck brake performance on the day of the incident.

The Murray Valley Highway intersects the rail line at an angle of about 40 degrees. It was estimated from the tyre skid marks that the truck deviated about eight degrees to the left of the highway. The angle of impact between the truck and the train was therefore estimated to be about 32 degrees. The impact angle is also consistent with the location of the broken rail as shown in Figure 3.

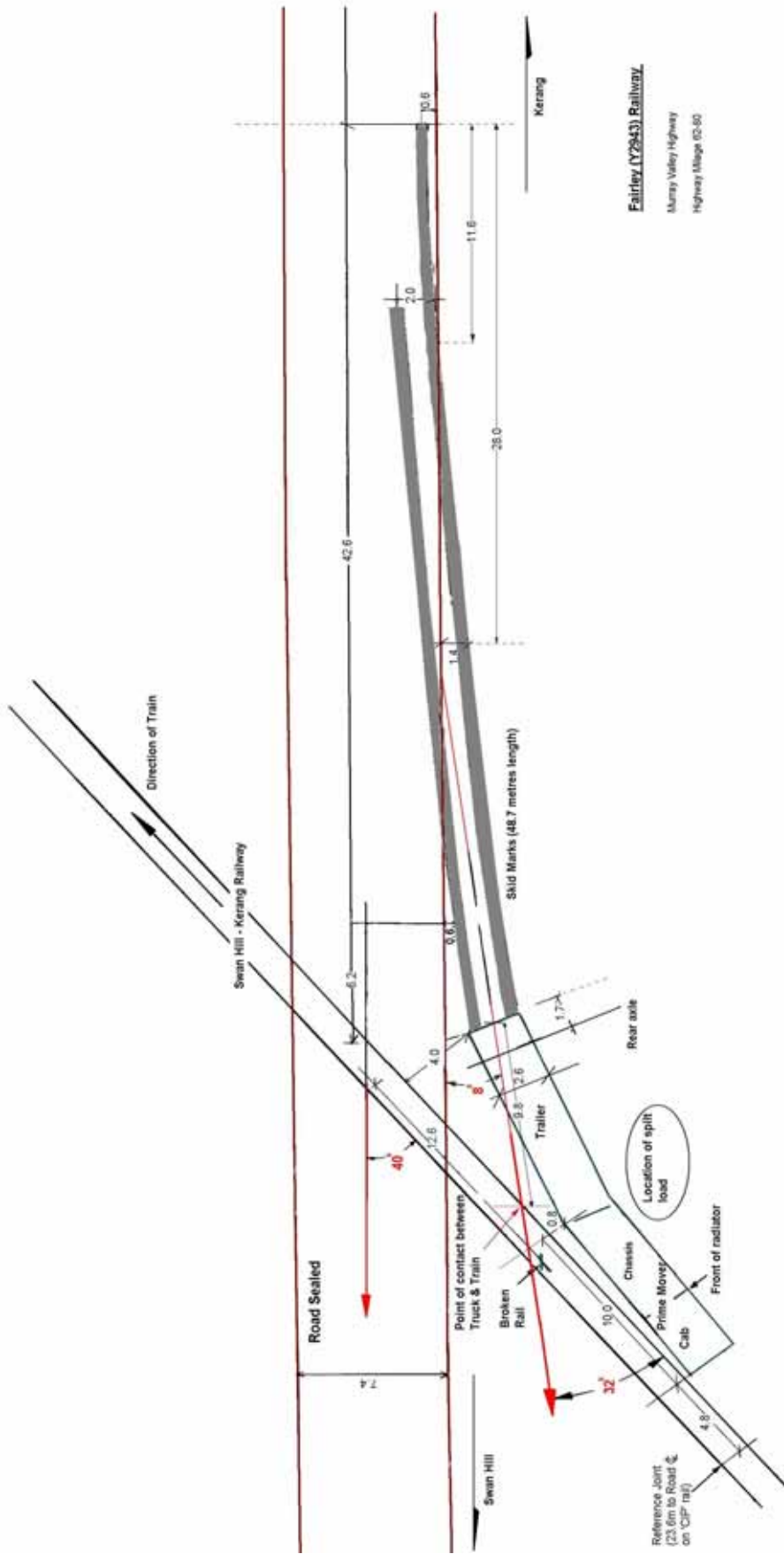


Figure 3. Track of truck to point of impact

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## 3.4 Incident consequences

### 3.4.1 Accident site overview

The land in the vicinity of the incident is flat and low-lying with the rail line elevated above the surrounding countryside. The only vegetation of note was a number of eucalypt trees situated to the south of the track and to the west of the level crossing.

Following the collision, debris from the train, the truck and the level crossing infrastructure obstructed the Murray Valley Highway and the rail line causing both the highway and the rail line to be closed to normal operations. The locomotive and first car of the train remained on the rail line with the leading end of the locomotive coming to rest 287 metres beyond the crossing. The second passenger car, the first to be struck by the truck, remained attached to the train, although the trailing bogie was derailed.

The third and last car of the train became detached from the remainder of the train following the failure of the draft yoke. The leading end of this car travelled 95 metres beyond the crossing with the wheels of both bogies derailed. All cars in the train remained upright and within the confines of the track ballast.

The prime mover and trailer came to rest to the west of the level crossing with the majority of its load spread in close proximity on the left side of the trailer (opposite side to the rail line).



**Figure 4. Truck as found with cab rotated forward, car BN19 in background.**

The right side of the prime mover was severely damaged with the front and drive wheels dislodged. One wheel and a separate tyre were found on the opposite side of the highway.

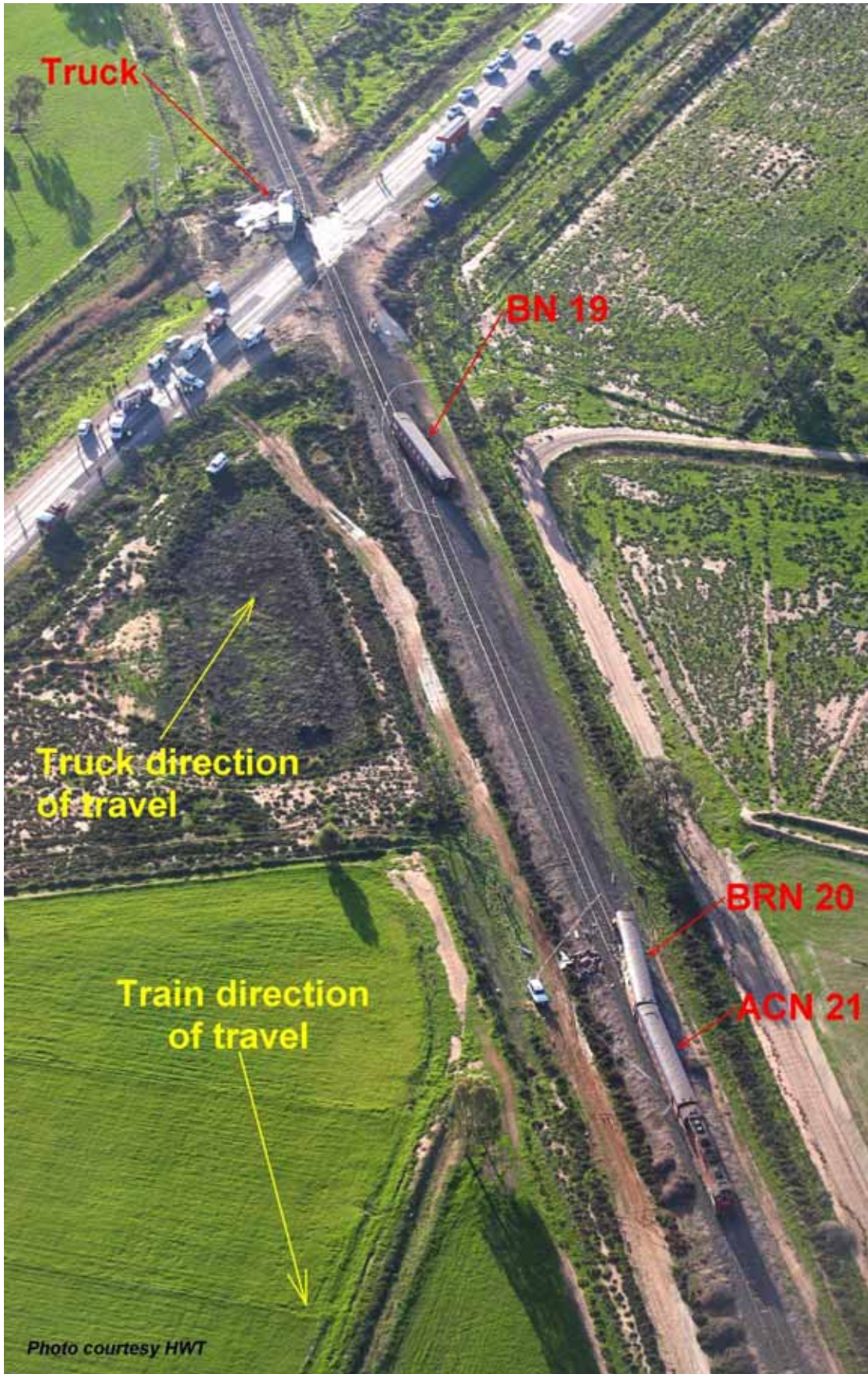


Figure 5. Overview of incident site

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### 3.4.2 Infrastructure damage

The Up rail (the rail on the north side of the crossing) was broken near a weld in the rail 12.6 metres prior to the centre of the crossing. The road surface at the crossing showed a number of rail wheel flange marks, some indicating that a wheel may have re-railed after initialing derailing. The road surface was covered in diesel fuel.



Figure 6. Looking towards Swan Hill, derailment marks (left) and broken rail (right)

To the east of the crossing, the track sustained significant damage. A significant number of timber sleepers between the crossing and where BRN20 came to rest were either destroyed or damaged. The rail after the crossing was also dislodged from the sleepers and distorted (Figure 7). The crossing relay box situated on the north side of the track about 36 metres from the crossing was damaged.

The main flashing lights facing the south were knocked over and destroyed along with the adjacent 'RAILWAY' crossing sign.



Figure 7. Sleeper damage (left) and rail displacement (right)

### 3.4.3 Train damage

Locomotive N460 and car ACN21 were undamaged. No evidence was found to suggest that either vehicle made contact with the truck or track-side infrastructure. Similarly, no evidence was found to suggest either vehicle left the track at any point in time.

Accordingly, detailed damage inspection focussed on passenger cars BRN20 and BN19 which were both extensively damaged in the incident. Damage inspections were conducted on 6-7 June at the incident site and on 26-27 June at Newport workshops. In undertaking the inspections, it was recognised that the cars were altered from their immediate post-incident condition initially due to the activities of the emergency services at the incident site and subsequently as a result of the relocation of the vehicles to Newport.

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## Passenger car BRN20

Of the two passenger cars, BRN20 suffered the more severe damage and incurred the majority of passenger casualties. BRN20 suffered extensive body shell damage on its A side, extending from just forward of the second window from its leading (East) end through the remaining length of the vehicle. Moving towards the rear of the car, the severity of damage progressively increased with full penetration of the body side from sole bar (floor) to cant rail (top of windows) commencing about 10 metres back from the east end.



Figure 8. An overview of damage to passenger car BRN20

The forward-most body side damage consisted of initial scuffing, progressing to heavier gouging, loss of windows and roof side damage above the windows. The forward most scuff marks were consistent with initial contact with the truck prime mover cab. The subsequent deeper marks and window damage were similarly consistent with progressive impact with the truck cab.



Figure 9. Initial scuff mark forward of the second window (right) progressing to window frame notch and gouging (left).

Penetration of the body side commenced with tearing of the sheet metal side panel just above the floor level. This tear progressively widened to the full height loss of the body side between sole bar and cant rail. The body-side panelling was concertinaed and pushed to the rear of the car. The initial tear and subsequent ripping of the body side was consistent with an override of the carriage sole bar by a flat rigid body, most likely to have been the tray of the truck trailer.



**Figure10. Initial tear (right) progressing to substantial loss of body side of BRN20**

On the B side of BRN20, the only body damage found was gouge marks at the rear of the car near the west end. The identified marks were consistent with BRN20 making contact with the track-side relay box which was also found to be damaged.

Damage to underframe equipment on BRN20 commenced from a similar point to the body-side damage. A number of items were damaged including the fuel tank, which was breached. The nature of the damage to underframe items on the A side of the car was consistent with impact by the lower parts of the truck, most probably wheels and lower structures of the prime mover.



**Figure 11. Underframe damage including breached fuel tank (left)**

Damage to the trailing bogie of BRN20 included the loss of the brake cylinder casing, consistent with heavy impact with the truck, most probably the low and heavier structures of the prime mover chassis (Figure 12).





**Figure 12. BRN20 trailing bogie, note damage to brake cylinder**

The damage to the interior of BRN20 was extensive (Figure 13). On the A side of the car, seat set 35/36/37 was dislodged and all seats to the rear of this set, from seat 42 back, were gone. On the B side, back-to-back seat sets 68/69 and 70/71 were gone, but all other seating was in-situ.



**Figure 13. Internal damage to BRN20, noting that dislodged seats had been removed by emergency services to assist the recovery of injured passengers.**

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The damage to seating included the failure of seat-to-floor connection bolts, bending of seating base plates and ripping of seat legs from seat frames. Failures were consistent with impact from an external object in the direction opposite to train travel, most probably the trailer of the truck.



**Figure 14. Bent base plate (left) and failure of upright to frame connection (right)**

Some of the damaged seats which remained in their mounted position were also found to be bent in the opposite direction to the train travel, suggesting impact by objects having a relative velocity towards the rear of the passenger car. This contrasts with the scenario in which a quickly decelerating train causes loose objects to move forward through the space.

Glass fragments from shattered windows were found throughout the compartment. The loss of several inner panes from the B side of BRN20 was consistent with impact damage from loose objects within the compartment.



**Figure 15. Glass fragments, seating bay 23/24/28/29 (right) and bay 30/31/38/39 (left)**

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## Passenger car BN19

BN19 suffered extensive side body and end damage at its leading (East) end on the A side. The damage included the loss of the corner end post, severe deformation of the outer gangway end post and extensive end and body side deformation. The more extensive body side damage extended for about five metres before leading to a 2.5 metre exit tear.



Figure 16. Overview of damage to BN19 leading (East) end



Figure 17. Initial point of impact on BN19 (left) and exit scar (right)

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The nature of the body damage to BN19 is consistent with a flat rigid body, most likely the tray of the truck trailer, impacting the front corner of the car causing the deformation to the gangway end post and then proceeding into the passenger compartment before exiting the space via the exit scar. The outward rolling over of the bottom edge of the exit scar suggests the tray was drawn out and down as it exited the body side.

Further to the rear of BN19 there were additional scuffs, minor dents and paint damage suggesting intermittent contact between the truck and passenger car BN19 as the train continued past the point of impact.

BN19 also suffered underframe damage which appeared primarily due to the derailment of the car and its subsequent interaction with track ballast. There was no evidence of significant direct impact by the truck on the undercarriage.

The damage to the interior of BN19 was confined to the leading end of the car and included seating damage, window debris and truck components (Figures 18, 19 & 20).



**Figure 18. Interior of BN19 looking forward**



**Figure 19. Damage to seat 5 (adjacent to window) in BN19**

The trailer refrigeration compressor was found between seats 10 and 19 on the B side of BN19 having been dislodged from its mounting position at the front of the trailer. The failure of the mounts and final location of the compressor are consistent with the truck trailer making heavy contact with the front corner of BN19.



**Figure 20. Truck compressor at bay 10/11/18/19 (left) and mounting position (right)**

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## Connection between BRN20 and BN19

### Draft yoke

Vehicles BRN20 and BN19 parted following the fracture of the draft yoke beneath the rear end of BRN20, as shown in Figure 21.



Figure 21. Fractured draft yoke at site, forward end of BN19 (left) and rear of BRN20 (right).

The remains of the fractured draft yoke attached to BN19 were removed from the site and subjected to metallurgical testing to assist in the determination of the mechanism of fracture and to identify any pre-existing condition which may have contributed to the fracture of the component. The component was found to have fractured at two locations as shown in Figure 22.

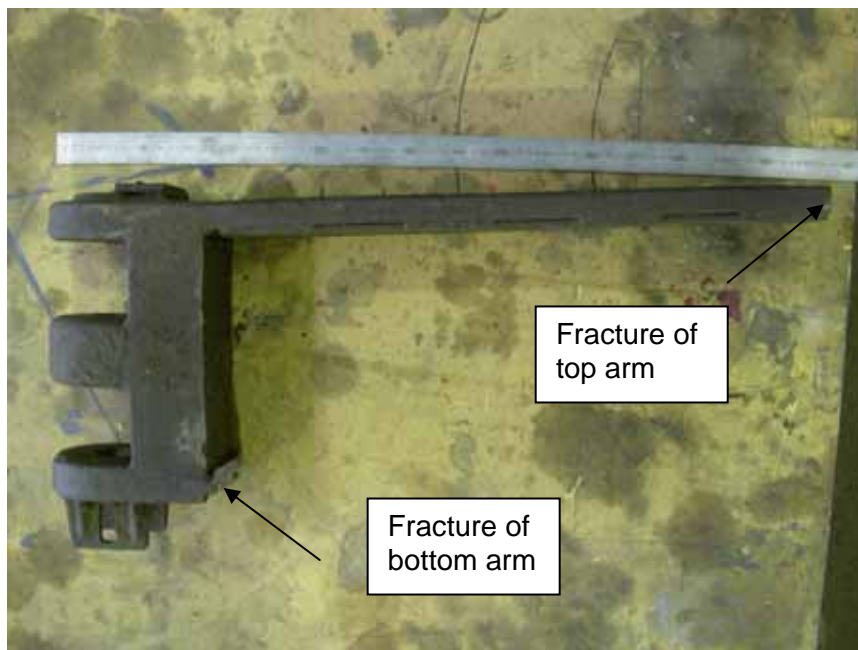


Figure 22. Tested draft yoke

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The primary fracture mode of the top arm appeared to be a tensile overload in moderately ductile material with no evidence of any progressive cracking mechanism present prior to failure. Two distinct fracture origins were observed on either side of the arm consistent with predominantly axial loading at the time of failure. Both fracture origins corresponded with the location of an original casting discontinuity.

The bottom arm showed a similar set of fracture features in the bulk section (overload in moderately ductile material) with the fracture origin at a casting discontinuity at the upper right hand corner. Some evidence of fatigue-like propagation of the fracture on the corroded region was observed, but was not considered conclusive. The fracture direction was right to left, no evidence of bending was observed on the left hand side, hence the final loading was considered to be predominantly axial.

In both fractures the origin discontinuities were considered to be original casting imperfections in the form of shrinkage or gas pores. Some evidence of fatigue growth of the discontinuity in the lower arm was observed but the level of corrosion even at the tip was consistent with a very slow propagation rate. Both regions of shrinkage were heavily corroded and appeared in somewhat similar condition to the external surfaces consistent with long term exposure. Evidence of other regions of shrinkage and gas pores was observed throughout the casting.

### **Striker plate**

The striker plate at the rear of BRN20 was heavily distorted, indicating that the coupler shank had been forced beyond normal operational limits. The damage was consistent with the rear of BRN20 being displaced laterally to the north of the track, away from the impacting truck (Figure 23).



**Figure 23. Rear of BRN20 showing distorted and damaged striking plate**

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### 3.4.4 Truck damage

The prime mover cab sustained damage to the front right corner consistent with it being the first point of contact with rail car BRN20. During the impact sequence the tilt cabin of the prime mover fell forward. The prime mover was damaged beyond economical repair.



**Figure 24. Prime mover during recovery with cabin returned to normal position**

The right side of the prime mover suffered significant damage with the loss of the front wheel and heavy damage to the drive wheels. Damage was consistent with the lower parts of the prime mover coming into contact with the passenger car undercarriage.

The trailer suffered extensive damage to its forward section, particularly to the front right side of the trailer tray and the refrigeration unit. Of note, as shown in Figure 25, is the upward bending of the front right corner of the trailer consistent with impact with and breaching of passenger cars BRN20 and BN19.





Figure 25. Overview of damage to prime mover and front, right of trailer



Figure 26. Prime mover right side drive wheel damage.

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### **3.4.5 Passenger location and injury distribution**

The movement of the passengers during the collision, their post-crash locations and injuries were compiled from the data provided by the surviving passengers, the conductors, the ambulance officers first attending the site and the Transport Accident Commission (TAC). Where there was conflicting evidence the investigation evaluated the evidence and a most probable position was adopted.

Apart from the fractures and heavy bruising due to trauma, of note is that a majority of the passengers in cars BRN20 and BN19 received facial lacerations and had pieces of glass embedded in their face.

#### **ACN21**

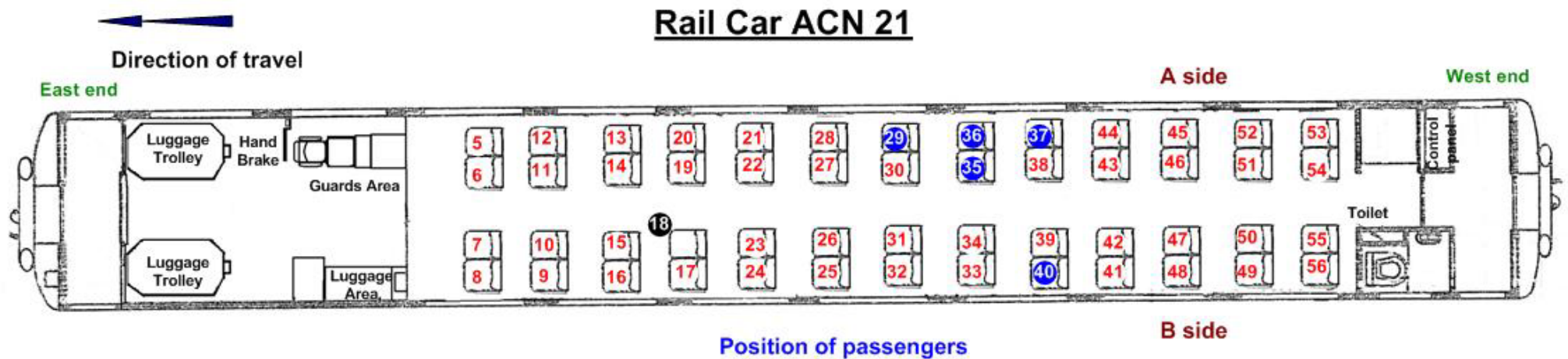
Rail car ACN21 (Figure 27) carried six passengers and except for one passenger who sustained some bruising, no physical injuries were sustained by the other passengers. The road vehicle made no contact with the ACN21. The passenger (seat 18) who sustained injuries in this car was standing up at the time of the impact and sustained bruising to the chest and right knee due to falling.

#### **BRN20**

A total of 21 seats out of the available 66 were occupied (Figure 28). Fourteen of the 21 allocated seats were on the penetrated A side of the car. Ten of those who received fatal injuries and 10 of the seriously injured passengers were located in this car. Nine of the passengers who received fatal injuries were seated on the A side with the tenth in seat 69 on the B side. In all 10 cases the seating was dislodged from its mounted position. In addition, the final location of passengers was mostly towards the rear of the car which is consistent with their seats being swept back along the saloon. The passenger in seat 69 appears to have moved to the front of the car after the collision.

#### **BN19**

Seven of the seats out of the available 88 seats in the car were occupied (Figure 29). One of the passengers in this car received fatal injuries and three others received serious injuries. The passenger who received fatal injuries was located in seat five and in an area directly impacted by the intrusion of the truck. Two of those injured in seats 10 and 19 were in the seating bay in which the refrigeration compressor was found. There were no reported injuries amongst the three remaining passengers.



**18** Right knee injury, bruised chest, back stiffness, neck pain (whiplash)

**29** No physical injuries reported

**35** No physical injuries reported

**36** No physical injuries reported

**37** No physical injuries reported

**40** Unknown

Figure 27. ACN 21 – passenger positions and injuries.

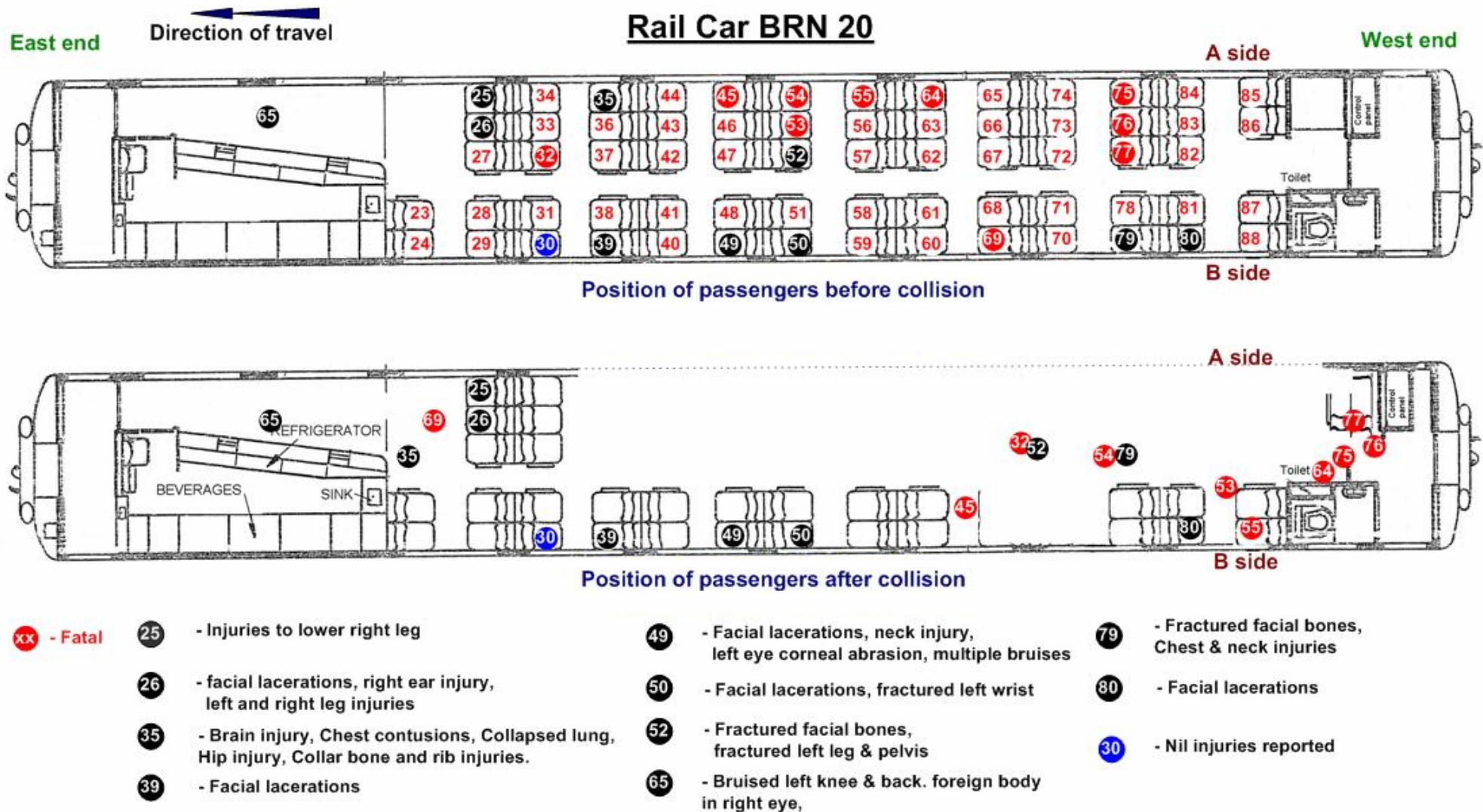


Figure 28. BRN 20 – passenger positions before and after collision and injuries.



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## **3.5 Infrastructure**

### **3.5.1 Rail network**

The rail track between Swan Hill and Kerang is a single line and is designated Class 3 with a maximum speed of 90 km/h for passenger trains. It is owned by VicTrack and leased to V/Line Passenger Pty Ltd which is responsible for track maintenance and the control of trains operating on the track.

'Train Orders' is the system for working trains between Swan Hill and Kerang. This system is paper based, managed by train controllers and applied by train drivers. The system prevents more than one train being in a single line section at the same time.

Two passenger services run in each direction between Swan Hill and Kerang each day of the week. From Monday to Friday services depart Swan Hill for Melbourne at 0735 and 1300, arriving in Kerang at 0814 and 1339. Trains depart Kerang for Swan Hill at 1127 and 2149, arriving at Swan Hill at 1210 and 2232.

### **Network communications**

Train controllers are responsible for the safe and reliable operation of all non-urban rail lines in Victoria. This is achieved through V/Line's control centre (Centrol) in Melbourne. Centrol is staffed on a 24 hours, seven days a week basis. The centre utilises telephone lines and a train-to-base radio network for communications. Train movements (paths) for the Swan Hill to Kerang line are plotted on paper graphs.

Any emergencies experienced by train drivers are reported to Centrol via the train-to-base radio. Centrol then take action as necessary to advise emergency services and the rail operator and to provide incident notification as required by legislation.

### **3.5.2 Level crossing**

The level crossing involved in the incident is known as crossing number Y2943 (Fairley). It is located 294.399 rail kilometres from the rail datum point in Melbourne and about six road kilometres north-west of the town of Kerang. The rail line passes through the crossing in a north-westerly to south-easterly direction (313–133 degrees True), with the Murray Valley Highway intersecting the rail line at an angle of about 40 degrees.

At the crossing the rail line is protected by active warning devices consisting of flashing lights and warning bells with approach warning signage and pavement markings.

The Victoria Government Gazette of 28 October 1999, Rule 123, states that a driver (of a road vehicle) must not enter a level crossing if warning (flashing) lights are operating or warning bells are ringing.

## Level crossing track layout

To activate the flashing lights and warning bells when a train is approaching a level crossing, the rail track is fitted with track circuits. The layout of the track circuitry for level crossing Y2943 is shown in Figure 30. The circuitry is inspected in accordance with the track manager's schedule every 48 weeks. The last inspection prior to this incident was conducted on 21 December 2006.

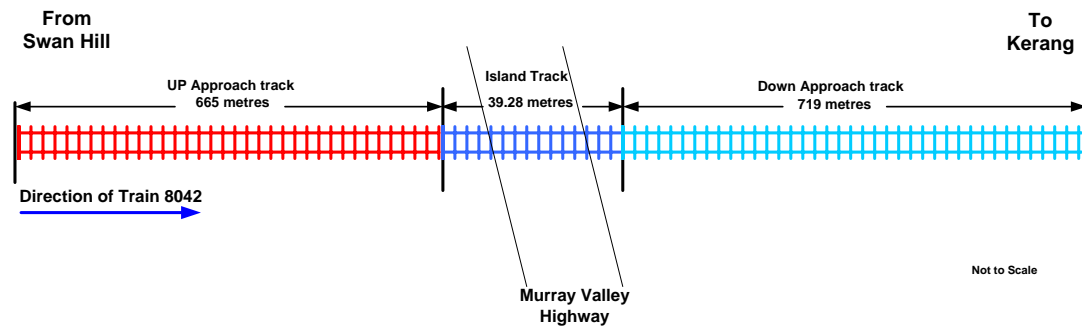


Figure 30. Murray Valley highway crossing track circuitry arrangement

## Level crossing warning time

'Warning time' is the time the warning devices are active prior to the train entering a level crossing. It is a critical design consideration for active level crossing traffic control. The intent is to:

- Provide sufficient warning to allow vehicles and pedestrians that have already entered the crossing to clear the protected area before the arrival of the train.
- Allow approaching vehicles that cannot safely stop before entering the crossing to continue through the crossing and clear the protected area before the arrival of the train.
- Allow the drivers of approaching vehicles that can stop before entering the crossing sufficient time to react accordingly and stop before reaching the crossing and / or any queued vehicles.

The minimum warning time that the warning devices shall operate before a train enters the crossing is specified in Australian Standard AS 1742.7-2007 as 20 seconds. In Victoria, the time the warning devices operate before the arrival of a train is generally set to between 20 and 25 seconds for flashing lights.

The crossing involved in the incident was fitted with a Safetran Event Analyzer Recorder (SEAR 11) monitoring device that records times of activation of the track circuits. An analysis of the SEAR monitoring device determined that the train took 24.87 seconds to travel between the two track circuits, a distance of 665 metres. As a result, the average speed of the train approaching the crossing was calculated to be 96.3 km/h. It was also calculated that the warning devices were activated for at least 25.4 seconds prior to the train entering the level crossing.

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## **Serviceability of warning devices**

During the incident sequence the truck collided with and removed the flashing lights and signage situated on the left side of the road immediately before the crossing. The flashing lights located on the right side of the road, and the warning bells, remained operational after the incident.

Two of the flashing lights that had been situated on the left side of the road were recovered substantially intact. Examination of the units found them to be type HC101 flashing light units with a lens diameter of 8.375 inches (about 21.27 cm). The units are considered an industry standard for use in highway level crossing protection.

Testing of the units found that when they were electrically powered, both units illuminated.

The main flashing lights (the lights on the left side of the road as this truck driver approached the crossing) are focussed to give an optimum sighting at 125 metres from the level crossing Stop line. The back lights (the lights located on the right side of the road) are focussed about 15 metres from the Stop line on the opposite side of the road. The type of lens used in the HC101 has a 30 degree spread and a 15 degree downward deflection. The flashing light aspect is visible from a distance of about 305 metres in a sight line. The last periodic check of the focusing of the flashing light unit was conducted on 4 April 2007. Because the flashing light unit was removed in the incident it was not possible to confirm the correct focusing of the lights facing the truck driver immediately prior the incident.

## **Australian Level Crossing Assessment Model (ALCAM)**

ALCAM has been designed as a tool for use in the risk assessment of road and pedestrian railway level crossings. It is a mathematical tool which models the characteristics of crossings and the protective controls present to determine the likelihood of given accident mechanisms occurring.

The model provides a risk exposure score for each crossing which enables the comparison of relative risk across all crossings within a jurisdiction.

The model has been approved by the Australian Transport Council of Ministers (ATC) and the Standing Committee of Transport (SCOT) as the national standard for the assessment of level crossings in Australia.

ALCAM has been adopted in Victoria as a tool to assist with prioritising level crossing upgrades. There is an ongoing program to assess Victoria's crossings using the ALCAM methodology.

As part of the above program, level crossing Y2943 was assessed in November 2006. As a result of the assessment a risk score of 78 was assigned and the level crossing was ranked at number 140 on a list of 143 crossings on the ALCAM interim prioritisation list.

## **Level crossing compliance**

Traffic control measures at level crossings in Australia are generally installed subject to the requirements of the relevant standards at that point in time. Australian Standards are periodically reviewed and revised, which over time, can result in non-compliance when an existing level crossing is assessed against the current standard.



It should be recognised that migration to a new standard, while desirable, is not mandatory.

At the time of the accident, Australian Standard AS 1742.7-2007: Manual of uniform traffic control devices Part 7: Railway crossings, prescribed the standard for road markings, road-side signs and active traffic control for use throughout Australia. AS 1742.7-2007 was published on 20 February 2007. Consequently, where non-compliances against the latest standard have been identified, additional comments have been made with reference to the earlier versions of AS 1742.7 published in February 1993 and June 1987.

An examination of road markings and signage at the level crossing identified slight variations from the requirements specified in AS 1742.7-2007. The illustrations in Figure 31 show the minimum traffic control requirements as specified in this Australian Standard and the actual traffic control installation at the level crossing at the time of the incident.

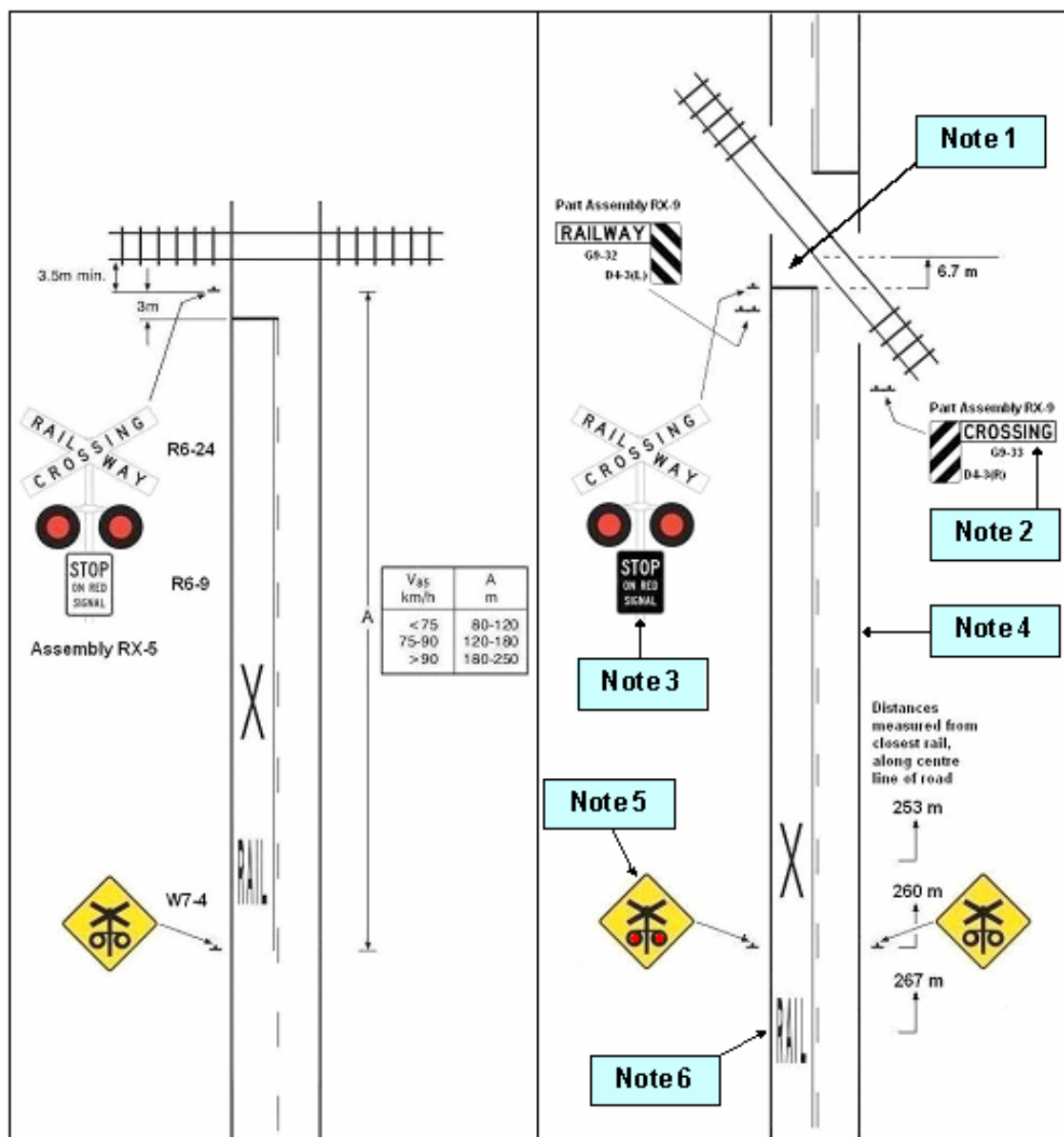


Figure 31. Signage as required (minimum) by AS 1742.7-2007 (left) and signage as installed at the Murray Valley Highway level crossing at Kerang on 5 June 2007 (right)

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Variations of note are:

Note 1 The position of the 'Stop Line' pavement marking did not conform to the current standard, which specifies that the 'Stop Line' be marked three metres before the flashing light assembly (RX-5). This is also a requirement of the superseded standards (AS 1742.7-1987 and AS 1742.7-1993).

Note 2 The optional 'Railway crossing width marker assembly' (RX-9) had been installed at the level crossing. The current standard states that this assembly should be used '...where the conspicuity of the crossing needs to be enhanced, typically on high speed rural road approaches.'

Note 3 The flashing light assembly (RX-5) conformed to the current standard except for the 'Stop on Red Signal' sign (R6-9) which is required to be formatted with black lettering on a white background. The 'Stop on Red Signal' sign (R6-9) installed at the crossing consisted of white lettering on a black background, which conformed to the earlier standard published in 1987 (AS 1742.7-1987).

The flashing light assembly (RX-5) was compliant, but not of the preferred design specified in the current standard for new or refurbished level crossing installations. The preferred design incorporates the 'Railway crossing position Target Board' (R6-25) shown at Figure 32.



Figure 32. Design R6-25

Note 4 The road approach to the Murray Valley Highway level crossing was curved, not straight, as illustrated in Figure 33. The current standard does not provide any additional guidance for curved approaches to railway crossings controlled by flashing lights.

Note 5 The placement of the 'Railway crossing flashing signal ahead' signs (W7-4) approximately 250 metres before the flashing light was consistent with a level crossing approach design based on 85 per cent of road vehicles travelling at greater than 90 km/h (V85). It was non-compliant with AS 1742.7 because the lights depicted on the sign were coloured red.

A second (optional) 'Railway crossing flashing signal ahead' sign (W7-4) was positioned on the right-hand side of the road. The current standard states that this sign '...may need to be repeated on the right-hand side of the carriageway for added emphasis, e.g. on high volume roads.'

Note 6 The pavement marking (RAIL X) was positioned central to the 'Railway crossing flashing signal ahead' signs (W7-4). While the current standard specifies that the markings should generally be 15 metres beyond the W7-4 signs, the standard also allows repositioning to ensure at least 50 metres clear viewing distance to the near edge of the markings. These are also requirements of the superseded standards (AS 1742.7-1987 and AS 1742.7-1993).

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## **Level crossing incident history**

Records held by Public Transport Safety Victoria (PTSV) indicate that only one previous fatal incident has occurred at this crossing, in 1995. Also, six near-miss incidents between trains and vehicles had been reported at the crossing between December 2005 and July 2006.

As a result of the near-miss incidents, on 1 August 2006, the train operator (V/Line) wrote to the then track manager, the Public Transport Division (PTD) of the Department of Infrastructure, the District Inspector of Police and the Shire of Gannawarra expressing concern at the behaviour of motorists at level crossings in the Kerang area. As a result of this correspondence a number of actions were taken by the various addressees. The police wrote an article about level crossing behaviour in the local newspaper and raised the issue in their segment on a local radio station. PTD added the crossing to its level crossing interim prioritisation list and conducted an ALCAM assessment in November 2006. The infrastructure manager inspected the general condition of the crossing and checked the operation of the crossing warning devices in August and September 2006.

### 3.5.3 Road

The Murray Valley Highway at the level crossing is a two lane, two way single carriageway that is managed by VicRoads under the Road Management Act 2004.

This section of highway links Kerang and Swan Hill. A traffic count taken in April 2004, at a point approximately 14 kilometres north of the level crossing, indicated that about 2316 vehicles used the highway each day. Of these, 25 per cent were estimated to be trucks (vehicles of axle load 4.5 tonnes or more). Anecdotal evidence suggests that the number of vehicles using the highway each day has not changed significantly since 2004.

At the level crossing the highway runs approximately north-south (354-174 degrees True). The highway alignment is such that a vehicle approaching the level crossing from Kerang will travel in a direction of about 338 degrees True and then at about 300 metres south of the crossing curve to the right, to head in a direction 354 degrees True at 106 metres from the crossing.



Figure 33. Aerial photograph of Murray Valley Highway

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## **Road design**

Austroroads (the association of Australian and New Zealand road transport and traffic authorities) has published the 'Rural Road Design – A Guide to the Geometric Design of Rural Roads'. 'VicRoads' 'Road Design Guidelines' incorporates the guidelines from the Austroroads manual. The section of the Murray Valley Highway in the vicinity of the level crossing was built in accordance with the VicRoads guidelines.

## **Road inspections**

In their road management plan, VicRoads have designated the section of highway in the vicinity of the crossing as Road Maintenance Category 4. Category 4 requires a hazard inspection to be conducted every second week in daylight hours and annually at night. In addition, an inspection is conducted on a monthly basis to check other road features, such as condition of signals, signage and markings, deformations and potholes and areas of 'ponding'.

The last day-time inspection prior to this incident was conducted on 30 May 2007, with the last night inspection on 7 May 2007 and the last monthly inspection on 16 May 2007. Pavement markings including the road 'Rail' and 'X' markings were last repainted in mid-June 2006.

## **Road surface composition and friction**

The road comprises a surface layer of bituminous material onto which a 14 mm sealing aggregate granite rock is placed. The most recent re-seal of the road surface at the crossing was done in 1998/99.

A road vehicle will skid when the available friction between the vehicle tyre and the road surface is insufficient to meet vehicle manoeuvring demands such as braking and turning. This is dependent on road surface type, weather conditions and the manoeuvring demands placed on the vehicle by the driver. Skid resistance data is collected by VicRoads using a specifically designed machine known as a Sideways Force Coefficient Routine Investigation Machine (SCRIM).

SCRIM records the sideways force coefficient and the differential friction level between the left and right vehicle wheel-paths. A test conducted on 25 June 2007 on the approaches to the level crossing found that both the sideways force coefficient and the differential friction level were well above the levels that VicRoads specifies as requiring further investigation, and therefore considered by them to be acceptable.

## **3.6 Environment**

Weather conditions at Kerang at 1330 on 5 June 2007 were assessed by the Bureau of Meteorology. The assessment found that it was a fine day with visibility estimated to be 50 km. The temperature was 11-12 degrees Celsius, the wind was south-easterly at seven to 15 km/h and the relative humidity was 80 per cent. There was between one and two oktas of cloud (one to two eighths of the sky obscured by cloud) at 2,500 feet (about 760 metres). The sun was at an elevation (above the horizon) of 29.7 degrees and at an azimuth of 342 degrees True.

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At 1342 on 14 June 2007 after the highway had been re-opened, a run was carried out to approximate the view that might be seen from a truck approaching the level crossing from the Kerang direction. The weather conditions were similar to the day of the incident but with a sky free of cloud. The run commenced about one kilometre from the crossing and it was noticed that there was considerable sun glare from the road surface, particularly from the two wheel tracks on each carriageway. After the bend in the highway, about 106 metres from the level crossing, the reflected glare from the road surface reduced significantly but was still present.

### **3.7 Emergency response**

At 1334:19 the '000' service received a telephone call from a private telephone number in the Kerang area. The call was connected to the ambulance. About two minutes later train control called the '000' service to notify the police of the incident. There were another four calls to '000' over the next one and a half minutes from private numbers in the Kerang area; all were put in contact with the police or the ambulance.

The first emergency service to arrive on the site was the ambulance from Kerang which arrived at 1350, about 16 minutes after the incident.

### **Rail communications post incident**

Immediately following the incident the train driver contacted Control using the emergency call function of the train to base radio. When the train controller responded the train driver advised that his train had just been struck by a 'semi' and the train had derailed, that he was 'the other side of Kerang and required ambulances'. The train controller acknowledged the driver. Train control was unable to contact the train driver again as they did not have his mobile phone number and the driver had left the locomotive and not set the train radio up for off-train communications.

The train controller then rang the '000' service and over the next 25 minutes spoke to police and ambulance emergency services. It was apparent from the Control tape of these conversations that the train controller was unaware of the exact location of the incident until around 1401. This is despite a phone call from the buffet conductor at about 1350 during which she advised the incident location and an estimate of those passengers who had received injuries. She also advised that police and the ambulance were in attendance.

### **3.8 Truck driver licensing**

Information provided by VicRoads indicated that after a driver obtained a heavy vehicle licence they were not required to undergo future training or assessment unless their licence was cancelled or lapsed for an extended period. However, at licence renewal drivers are required to advise if they have certain medical conditions.

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### 3.9 Human factors

To assist the investigation, the Australian Transport Safety Bureau (ATSB) was engaged to conduct a survey of the site and provide specialist human performance analysis. The investigation has drawn on information provided by them and other human factors experts.

#### 3.9.1 Sighting from the semi-trailer approaching crossing

From the information obtained from the site survey along with data from the locomotive event recorder and estimations of the performance of the truck it was possible to create a computer animation of the assumed incident sequence. This, along with observations from a similar truck to that involved in the incident and other site observations, were used to estimate what the truck driver should have been able to see as he approached the level crossing.

Figures 34 and 35 provide a view from a distance of 360 metres from the crossing and 100 metres before the advance warning sign (W7-4).

Figure 34 indicates that the flashing light assemblies are visible. However, because of the focusing of the flashing lights their visibility to a road user is not guaranteed beyond 305 metres from the crossing.

Figure 34 also indicates that the train appears as a relatively small object partially visible through the trees and may not have been detected by the truck driver.



**Figure 34. The estimated view from truck cab 360 metres from the level crossing stop line and 100 metres from the advance warning sign**

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In Figure 35 a depiction of the front section of the cab (except for mirrors and the stone guard) has been superimposed to demonstrate potential obstructions to the driver's view. The vehicle that is stationary at the crossing is partially obscured by the driver's side A-pillar of the truck; however, this obstruction could be circumvented by appropriate movement by the truck driver.



**Figure 35.** A view showing the potential influence of the driver's side A-pillar on seeing the crossing lights and stationary vehicle. Note the central 'pillar' is an external support for windscreen stone guard.

Figure 36 shows the estimated view from the truck cab at 260 metres from the level crossing; at about the location of the advance warning sign and still about nine seconds prior to the collision. The flashing light assemblies and stationary vehicles are visible. The train at this point is mostly obscured by the trees.



**Figure 36.** The estimated view from the truck cab at the advance warning sign 260 metres from the level crossing stop line.



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It is not until approximately 106 metres from the crossing (Figure 37) that the truck reaches the straight section of the road. At this point, it is estimated that the truck was travelling at a speed of 100 km/h (27.8 m/s). Both flashing lights are clearly visible and should have been visible through the windscreen to the driver, as should any stationary vehicles at the level crossing. The distance from the end of the curve to the estimated commencement of braking (about 55 metres) would have been covered in approximately two seconds, assuming no change in vehicle speed.



**Figure 37. The estimated view from the truck cab 106 metres from the level crossing stop line.**

### **3.9.2 Human information processing**

Attention is a complex process which refers to the capacity of an individual to maintain some level of alertness during their activities. Attention involves a narrowing of an individual's focus. Failures of attention can occur when distracting or unnecessary information intrudes on processing. Under such conditions the road user's attention can become focused on information that is unrelated to the driving task.

Muttart (2005) has suggested that there are appropriate and inappropriate contributors to inattention to a road hazard. Inappropriate attention could take the form of talking on a mobile phone or adjusting radio settings. Appropriate attention could take the form of checking the speedometer reading or attending to the movement of road traffic on the road ahead. Any of these activities, whether appropriate or inappropriate could lessen the likelihood of detecting a hazard, such as a previously concealed cyclist who suddenly emerges from a side street.

A driver's reaction time is used to assess the swiftness with which they respond to a potential hazard. Reaction time encompasses the time from when the object is first detected and identified, through interpretation of the object's meaning, determination of how to respond and the execution of response actions. The number of possible ways to respond to a hazard can greatly influence the overall reaction time.

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A reaction time of 2.5 seconds is generally used in the road design context as the majority of drivers unalerted to a more urgent situation are able to respond in that time frame (Austroads, 2003; Lay, 1985). This value however does not include the time for the driver's actions to affect the vehicle's stopping or acceleration performance. In addition, research has found wide variance in driver reaction times ranging from fractions of a second up to approximately seven seconds (Triggs & Harris, 1982).

The driving task is relatively complex, requiring an individual to allocate cognitive resources to manipulating the vehicle's controls, maintaining lane position, scanning the external and internal environment and navigating the intended route. For this incident there is little information available on the truck driver's actions in this regard. However, evidence suggested that, at least in the latter stage of his approach to the crossing, he was scanning the road ahead of him since he had detected the stationary vehicles on the opposite side of the level crossing. After detection of the vehicles he then observed the flashing lights at the level crossing and then shortly thereafter, the train.

Central vision is a very narrow view ranging from approximately one to two degrees in either direction from a fixed point. The field beyond this is referred to as peripheral vision. It is therefore more likely that a potential hazard would present itself initially in a driver's peripheral field of view (Muttart, 2005). Depending on the direction the truck driver was looking and due to the curved approach, the animation suggested that the active flashing lights and / or train may not have consistently been in his direct line of sight.

It is not known at what distance from the level crossing the truck driver became aware of the stationary vehicles, level crossing flashing lights and the train; nor the number of potential responses the truck driver considered when attempting to avoid the train. In addition, it is not known what he was focusing on as he approached the level crossing. For whatever reason, there may have been a delay in initially detecting and interpreting the active level crossing lights. It is not known whether he was distracted, either appropriately or inappropriately during his approach to the level crossing, or if there were any other factors that may have influenced his ability to detect and process visual information.

## **1. Fatigue**

Fatigue is considered to be caused by a lack of restorative sleep<sup>3</sup>. This can be contributed to by the time and place of work, the length of time spent at work, and the amount and quality of rest obtained prior to and after work periods.

Reports indicate that the truck driver arrived at his place of work in preparation for the trip to Adelaide at about 0900, for a scheduled departure at 1000. The truck did not depart until about 1030. Therefore at the time of the incident the driver had been 'at work' for four hours and thirty minutes and driving for about three hours. Legislation in Victoria requires that a driver of this type of vehicle take a thirty minute rest after driving for a period of five hours.

Prior to the day of this incident the truck driver had been on recreational leave for four weeks. His activities in those weeks are unknown as is the potential for any cumulative fatigue to be present prior to starting his work day.

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<sup>3</sup> Commonwealth House of Representatives Standing Committee on Communications, Transport and the Arts report Beyond the Midnight Oil, October 2000.

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## **2. Illness**

Long term or short term illnesses have the potential to affect a driver's attention to the driving task. No information was available to the investigation as to the driver's state of health at the time of the incident.

## **3. Contrast of signals and train with background**

Contrast refers to the difference in brightness (or luminance) between an object and its background. Contrast plays an important part in many visual tasks, such as discriminating objects in complex visual environments or being able to read a road sign. Level of contrast can determine whether an object can be easily identified, or is intense enough to draw a road user's attention away from what they are currently focusing on (Most, Simons, Scholl, Jimenez, Clifford and Chabris, 2001).

When the sun is either directly or indirectly visible to a road user it can cause physical discomfort and potentially diminish an individual's ability to use visual information from the environment. Glare occurs when the visual field brightness is greater than the luminance to which the eyes are adapted (Mace, 2001). Discomfort glare results in discomfort, causes fatigue and may produce pain. Disability glare impairs the eye's ability to distinguish small changes in brightness, thus reducing the visibility distance of low-contrast objects. Individuals also differ in their sensitivity to glare.

The effect of sun glare can be amplified by imperfections (distortions) or damage (chips) to the vehicle windscreen, including dirt. The condition of the windscreen of the truck prior to the incident could not be determined.

The distinctiveness of signals tends to be reduced under conditions where their luminance level is similar to the background, as occurs in bright sunlight. Hence the contrast between the signal and its surrounds may be less. Under conditions where there is also reflection from the road's surface it is possible that the conspicuity of signals may be reduced.

In this incident the sun was almost directly ahead of the truck throughout the approach to the level crossing. From this position, it is possible that sunlight was being reflected off the road's surface, potentially affecting the driver's visibility of the warning signage and the level crossing flashing lights. It is not known whether the truck driver wore vision-correcting glasses or sunglasses which modified the effect of glare.

The position of the sun at the time of the incident also meant that the side of the train facing the truck driver was shadowed. Consequently, the contrast between the train and its background is likely to have been reduced and less easy to detect.

Some rail operators in Australia configure locomotive ditch lights to flash when the locomotive warning horn is activated to assist in increasing the conspicuity of the locomotive. This is not the case with V/Line locomotives.



**Figure 38. Photo taken from the advance warning sign at about 1335 on 14 June 2007 as the scheduled train approached the crossing. Note: sun glare from the road.**

#### **4. Train horn**

The locomotive's horn was sounded twice on the approach to the level crossing. On the first occasion, near the whistle board, it was recorded as active for less than half a second. Subsequently, it was sounded continuously from 140 metres prior to the crossing until impact: a period of seven seconds.

When passing a whistle board, the Victorian Book of Operating Rules and Procedures 1994 requires the train horn activation to be a long whistle that should be distinct and used in proportion to the distance at which it is required to be heard<sup>4</sup>.

The United States National Transport Safety Board (NTSB 1996), in cooperation with several Oklahoma based companies<sup>5</sup>, conducted research on the audibility of train whistles in different types of road vehicles, including a 1997 Thomas / Ford school bus, a 1996 Freightliner conventional truck-tractor, and a 1986 Chevrolet Corvette. The study measured the amount of insertion loss<sup>6</sup> that occurred with each vehicle and also the audibility level of the train whistle under different vehicle conditions (windows up with engine at idle and air conditioning fan on high). The train whistle sound level was 96 dB(A)<sup>7</sup>, 100 feet (30.48 metres) from the vehicle. In seven of the 13 vehicles tested the train whistle was not audible over the fan and engine at idle

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<sup>4</sup> The Book of Rules and Procedures 1994 section 10 rule 1.

<sup>5</sup> Oklahoma Operation Lifesaver, Oklahoma Department of Transportation, and Burlington Northern Santa Fe Railroad.

<sup>6</sup> Insertion loss refers to the difference between the measured sound values from an exterior sound source taken outside the highway vehicle and inside the vehicle (NTSB, 1996).

<sup>7</sup> The decibel (dB) is a logarithmic unit used to measure sound. The A scale is a filter that responds to frequency in a similar way to the human ear.

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noise (for full details see NTSB, 1998, report number PB98-917004). This study did not include other potential noise sources such as radio / music, engine noise above idle, or road noise generated by a moving vehicle. The study concluded that these results underestimated the level of interior noise that would be present under normal driving conditions.

The main horn on the locomotive involved in this incident was tested and found to comply with the appropriate ROA standard. Due to the damage sustained by the vehicle it was not possible to conduct an assessment of the insertion loss properties of the truck.

In this incident, the first use of the train horn was recorded as active for 0.35 seconds at a distance of about 450 metres. Given the available information, the distance of both the train and truck from the crossing, and the presence of trees between the two vehicles, it is considered very unlikely that the first horn blast would have alerted the truck driver to the train's presence, nor to the necessity to take action. When the horn was sounded the second time, event recorder information indicated that the train was approximately 140 metres from the crossing and the horn was active for seven seconds. It is not known when or if the truck driver was alerted to the horn or if the horn would have been audible inside the truck.

## **5. Expectation and familiarity**

The National Transportation Safety Board (NTSB) in 1998 conducted a study of drivers involved in accidents at passive level crossings. They discovered that an important factor that influenced whether a road user looked for a train was their expectation of seeing one. In this study the NTSB interviewed 18 vehicle drivers involved in level crossing accidents and found that they underestimated the frequency of train crossings per day by a factor of two or three. For example, one road user involved in an accident traversed the grade crossing on a daily basis and estimated that there were three to six train crossings per day when the actual number was 17. Low estimates indicate that road users do not expect to see trains and consequently may not look for them at a crossing.

Although these findings relate specifically to passive level crossings, a similar effect may occur at active crossings with flashing lights. If the road user does not expect a train to be present then they may not expect to see the flashing lights.

The perception of a road user that a train is unlikely to be traversing the crossing is reinforced every time they go over the crossing without seeing a train. Research conducted by Schoppert and Hoyt (1968) found that a person's response to a possible hazard is influenced by both the perceived probability of the adverse event occurring and of that person's understanding of the severity of the consequence of the event (cited in NTSB, 1998). Furthermore, an individual's perception of the probability of a particular event occurring is strongly influenced by past experience (Schoppert and Hoyt, 1968 cited in NTSB, 1998), and the frequency with which they encounter a train at a crossing will influence the likelihood of that road user stopping (NTSB, 1998).

An additional factor that may influence a road user's behaviour at a level crossing is their level of familiarity with it. Research indicates that familiarity with a level crossing does not necessarily reduce an individual's risk of having an accident, especially if trains are infrequent on the crossing (Wigglesworth, 1979 cited in Caird, Creaser, Edwards, and Dewar, 2002). In a study involving passive level crossings, Caird and others (2002) determined that crossing familiarity combined with the expectation that

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a train will not be present has the potential to lull motorists into becoming complacent or developing poor looking habits. Although this research addressed passive level crossings, the same conclusion may be drawn for active level crossings. However, the warning systems fitted to these road / rail interfaces should reduce this effect because they provide a clear indication that a train is present.

The primary function of a warning system is that once activated it is designed to draw an individual's attention. Consequently, there would be an expectation that the warning system would indicate the presence of a train (Tidwell and Humphreys, 1982; Richards and Heathington, 1988; Wigglesworth, 1990, cited in Wigglesworth, 1992). Once activated, it would be expected that the intended recipient knows what it indicates and the appropriate actions to take.

Reported information indicated that when the truck driver normally drove this route he arrived at the Murray Valley Highway level crossing at Kerang around 1300. However, on the day of the incident there had been a delay during loading. Consequently, he was 30 minutes behind schedule and this placed him approaching the crossing at approximately the same time as the scheduled train. It is not known whether the truck driver had seen a train at that crossing in the past, or seen the signals activated, nor whether he had ever needed to stop at the crossing. Furthermore, there were only four scheduled trains a day for that track. If the truck driver did not expect to see the train, this may have influenced both his search for the signals and also their interpretation. Although the flashing lights were reacted to in the current incident this only occurred after he had seen the stationary vehicles. The signals themselves may therefore not have drawn his attention to the presence of a train as swiftly as intended.

The provision of advance warning information to road users regarding potential or actual hazards ahead of them is likely to enhance their response to the situation (Muttart, 2005). Although advance warning signs were positioned 260 metres from the crossing it is not known whether the truck driver saw them. Furthermore, given his familiarity with the level crossing, the low amount of rail traffic and his likely low expectation of encountering operating flashing lights indicating an approaching train, it is possible that he had developed poor scanning habits. This may have influenced his delay in detecting the flashing lights and train.

## **6. Inattentional blindness**

The investigation interviewed a small sample of truck drivers in the Kerang area that were experienced in long-haul operations. The drivers reported that in their experience on the open road, a driver's focus narrows and they believed that they were not necessarily fully aware of the entire environment around them. They also mentioned that it was rare to hear a train warning horn in country driving.

This inattentional blindness ('blank stare') phenomenon is the failure to see an object because attention is not focused on it. Research conducted in this area<sup>8</sup> indicates that in performing tasks such as operating a vehicle, the operator may fail to see what should have been plainly visible and afterwards, cannot explain why. If an object, of its own accord, captures our attention it is 'conspicuous', however if we focus attention on too many things at once we may miss something that is critical. Additionally, expectation affects our ability to see and to notice. Our past experiences exert a strong control on attention because we 'learn' what we believe is and is not relevant. Expectation may encourage us to see what is not there and it

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<sup>8</sup> Green, M. (2004) Visual Expert Human Factors: Inattentional Blindness & Conspicuity.

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can also make us miss what should be obvious. Another cause of 'blank stare' is low arousal caused by too moderate a mental load. When people become bored they cease to pay close attention and their attention wanders. Green states: *"People may ...go on 'auto-pilot' when performing highly practised tasks, such as driving."*

### **3.10 Passenger car crashworthiness**

This incident represents a very severe impact between a loaded semi-trailer and rail passenger cars. Based on an estimated train speed of about 96 km/h, truck speed of 60 km/h and collision angle of 32 degrees off head-to-head, the magnitude of the relative velocity between the vehicles is approximately 150 km/h.

#### **3.10.1 Body Structure**

Built between 1981 and 1983, the N Class passenger car structural design was based on the Victorian Railways Z Class built between 1956 and 1960. Accordingly, its structural design preceded recent developments in crashworthiness.

#### **Side impact (BRN20)**

V/Line advised that a side impact loading condition is not a design requirement of the N Class passenger car. Structural design is principally based on end loading which in turn provides a level of inherent side body strength.

This absence of side-impact loading scenarios is consistent with the design methodology for most modern rolling stock which generally also focuses on end-on collisions. The key advance in crashworthiness with modern rolling stock is the incorporation of energy absorption capacity within vehicle ends.

The approach to side impact and the side strength of most contemporary passenger carrying vehicles is not significantly different to the N Class cars. Comparison between the N Class cars and modern carbon steel rolling stock suggest that the N Class cars would not compare unfavourably given that:

- the external skin is of a thickness comparable to modern rolling stock;
- body side framing is comparable to modern rolling stock in terms of both the sections used and the spacing of the sections; and
- the materials used have similar structural strength properties.

Given this similarity in body-side structural strength, a similar collision with a modern vehicle would be expected to yield a similar level of structural damage to that of BRN20.

#### **End impact (BN19)**

The N Class car resistance to end-on collisions is concentrated in end posts either side of the gangway. The end posts on the extreme corners of the carriage are light by comparison and in this instance would have provided limited resistance to intrusion. The heavier end posts at the gangway were sufficient to prevent intrusion of the trailer corner and deflected the trailer away from the train.

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By comparison modern rolling-stock typically has greater strength at the corners of the carriage. Whether an alternative structural arrangement would have resulted in less intrusion was not ascertained by the investigation.

### **3.10.2 Interior and survivability**

#### **Seating design**

Seating is typically designed to withstand 'g' loading of passengers bearing on the seat as a train rapidly decelerates as in the case of a head-on collision. By contrast, in this incident loading on the seats was due to the intrusion of the road vehicle into the passenger compartment.

Seating in the N Class car is a proprietary item and no specific design standard for the seating was identified by the investigation. While the loading scenario in this instance is not what would normally be considered in seating design, the nature of the seating failures identified the following potential weaknesses:

- the flat plate feet offers limited resistance to bending;
- the fixtures connecting flat plate feet to carriage floor may have limitations;
- the lack of bracing between seating legs increases the susceptibility to collapse; and
- the nature of welded connections between legs (uprights) and seat base frame provide a potential point of weakness.

Given the nature of the incident and specifically the intrusion of the road vehicle into the passenger compartment, it is unlikely that the seating design would have had a significant impact on passenger injury outcomes.

#### **Window materials**

The windows of the N Class passenger cars are double glazed. Each pane is 6 mm toughened glass meeting the requirements of AS 2080. Toughened glass has the advantage of the relatively safe fragmentation of the glass.

The investigation found that the glass performed as expected in the incident.

The use of toughened glass compares to more recent rolling stock which typically has single pane laminated glass to a specified rail industry standard, including anti-spall properties. As a consequence, more modern designs would be expected to have a lower level of glass injury than that experienced in this incident.

For existing double glazed, toughened glass installations, treatment options include the application of film products on the inner pane.

#### **Insulation dust**

The N Class car is insulated with a limpet mineral fibre. In the incident, passengers reported widespread dust, most likely a combination of the insulation material from the breached body side and ballast dust resulting from the derailment.

Modern rolling stock typically uses other forms of insulating materials such as fire retardant polyester. Such materials do not produce high levels of dust.



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### **3.10.3 Conclusion on crashworthiness**

The level of performance achieved by passenger cars BN19 and BRN20 was similar to that which would be expected from modern rolling stock in the same circumstances. With respect to the loading scenario in this incident, relevant differences in design and construction are:

- the strength of corner end posts;
- potentially, the strength of seating;
- the type of glass used in windows; and
- the type of insulation.

Notwithstanding the above differences, in certain respects the N Class car is superior to certain more modern rolling stock. It would therefore be inappropriate to consider the N Class car deficient because of one particular load case.

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## 4. ANALYSIS

This incident resulted from a road vehicle not stopping at a level crossing at which active warning devices were operating. The subsequent impact with a passenger train resulted in fatal injuries being sustained by 11 passengers and a number of other passengers and the truck driver receiving serious physical injuries.

### 4.1 Impact sequence

A north bound truck collided with a locomotive hauled passenger train at an estimated relative (closing) velocity of 150 km/h. The angle of impact between the train and the truck was about 32 degrees.

The truck was found to have made initial contact with passenger car BRN20. Evidence suggests that initial contact was made by the cab of the truck and lower parts of the prime mover as the collision progressed.

Side damage to BRN20 indicates that the corner of the trailer tray rode up above the passenger car sole bar (floor level) resulting in penetration of the passenger compartment. The most probable scenario is that the trailer then continued along the length of the passenger compartment, breaking seats away from their mounts and creating a front of debris which swept back through the space.

This scenario is consistent with the injury data which shows that except in one case, all those fatally injured had been sitting on the A side of BRN20 in seats which had been ripped from their mounts. The passengers were found towards the rear of the compartment indicating they had been propelled in this direction. The other passenger fatally injured in BRN20 is believed to have been sitting on the B side, but also in a bank of seats bodily removed in the collision.

At some point in time during this progressive collision with BRN20, the more rigid lower parts of the prime mover impacted the rear bogie of BRN20. This heavy impact was the most probable cause of the fracture to the Up rail and derailment of the rear bogie of BRN20. This sudden lateral movement of the rear of BRN20 is also expected to have resulted in the distortion of the coupler striker plate.

The heavy impact between the prime mover and the bogie may have caused the prime mover to rebound as the trailer and debris continued to sweep the passenger saloon.

Due to lateral movement of the rear of BRN20 away from the truck, the depth of penetration of the trailer corner would have begun to diminish, resulting in a shallow exit from the rear of BRN20.

At this time, it is probable that the leading end of BN19 was still running reasonably straight and accordingly presented its forward surface to the front corner of the trailer. The trailer tray, which now had an angled orientation, then impacted heavily on the gangway outer end post resulting in significant deformation and energy absorption.

This impact would have placed the draw gear in severe tension and in combination with the additional loads on the draw gear due to the lateral displacement of BRN20. This was probably the instant at which the draft yoke fractured, leading to the parting of BRN20 and BN19.

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The trailer corner appears to have continued through BN19 and rebounded away from the train, exiting the body side. The passenger who sustained fatal injuries in BN19 was sitting in the forward-most window seat in the area of the car that sustained the most damage.

The locomotive, undamaged ACN21, and the coupled but derailed BRN20 continued towards Kerang, initially under partial braking, as a result of the brake hose being parted, and then emergency braking after it was selected by the driver. The rear B side corner of BRN20 made contact with the track-side relay box.

Following its separation from the train and in part due to the energy absorbed as the truck impacted its front end, BN19 would have rapidly slowed. The mechanism leading to the derailment of the front bogie of BN19 could not be determined with certainty, but it is likely to have occurred during the collision.

The prime mover and trailer were found to have moved only a short distance from the original impact point, the prime mover coming to rest nearly parallel to the track with the driver's cabin rotated forward to lay the windscreen down on the ground. The front trailer corner remained in a raised position with the rear of the trailer offset from the track without sustaining any direct impact damage.

## **4.2 Human factors aspects**

### **4.2.1 Truck and driver**

There was no evidence found to indicate that the design, manufacture or condition of the truck contributed to the collision.

The truck driver was reported to have been diligent in his work and to have had a good heavy vehicle driving record. However, attempts to determine his actions, physical wellbeing and state of mind prior to the incident could not be addressed because of his refusal to submit to an interview for this investigation.

This leaves three broad scenarios:

- the driver observed the warning devices and decided to continue over the crossing intending either to pass in front of or behind the train;
- the driver perceived the warning devices but took too long to interpret and react appropriately; and
- the driver did not become aware of the activated level crossing warning devices and the approaching train until it was too late to avoid the train.

Given the collision scenario, the first would require a significant error of judgement for an experienced truck driver.

The second scenario could involve the driver not fully perceiving the potential danger indicated by the passive advance warning signage then not reacting appropriately to the flashing lights.

If the third scenario were true then the driver was not concentrating appropriately on the driving task.

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It was not possible for this investigation to determine if any of the issues addressed in section 3.9 of this report, either singularly or in combination, influenced the truck driver's performance.

Fatigue and illness are issues that are not easily controlled by the wider transport sector and are more dependent on individual drivers and their employers.

The investigation determined that the flashing lights were activated when the truck was about 700 metres from the crossing. Also, that there was no impediment to the flashing lights being sighted from at least 300 metres and that the advance warning sign, located about 260 metres from the crossing, should have provided an adequate opportunity for the driver to observe the flashing lights and stop his truck prior to the crossing.

What effect the position of the sun and any associated glare had on the driver not observing the various warning devices cannot be determined. However, if the driver was affected by sun glare then it would have been prudent for him to adjust his driving to the conditions.

Also, there is a need to attempt to break any narrow focus or inattentive blindness by drivers and alert them more adequately to the presence of a level crossing and to the presence of a train about to enter that crossing. This could be done by the provision of active warning devices at a similar distance from the crossing as the current passive advance warning signs.

In this incident, given that the level crossing was equipped with flashing lights, the visibility of the train should not have been an issue. What was required of the truck driver was to comply with the flashing lights; however, there was potential for a more visible train to have provided an additional cue to the driver's observation. There may be a case for improving the conspicuity of trains by providing locomotive ditch lights that flash when the locomotive warning horn is sounded.

## **4.3 Rail operations**

### **4.3.1 Train operation**

The authorised line speed for the track immediately prior to and at the level crossing is 90 km/h. The Victorian Book of Rules and Operating Procedures 1994 require that train drivers regulate the running of the train to remain within the authorised speed. There is no allowance in the Book of Rules for a train to exceed the authorised speed. However, the operator's Driver Point Demerit procedures permit a driver to exceed the authorised line speed for short distances for train handling considerations, by up to 10 km/h without any disciplinary action. This allowance of minor short term variations in the train speed seems reasonable.

In this incident, the speed of the train as it approached the level crossing could be determined from two sources; the locomotive event recorder and the crossing equipment monitoring device. From the event recorder the speed was determined to have been a constant 92 km/h from about 680 metres prior to the crossing until the crossing. This speed was presented to the driver on the cabin instruments. The investigation determined that because of a variation in the wheel size from that programmed in the event recorder the corrected train speed would have been 94 km/h. Analysis of the crossing equipment monitoring device found that the train

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speed between the first track circuit, 680 metres prior to the crossing, and the level crossing was slightly over 96 km/h. This minor variation between the two recording systems and the fact that the actual train speed was marginally in excess of the authorised line speed were not material to this incident.

### **4.3.2 Train control**

When the driver first reported the incident to Control he advised the train controller that the train was located on the “other side of Kerang”. While this explanation of the of the train’s position is not specific it would appear reasonable to assume that, given that the train controller is located in Melbourne and the time the incident was reported was prior to the scheduled time at Kerang, he would have believed that the train had not yet arrived in Kerang. Despite this, about 25 minutes was spent by train controllers attempting to accurately position the incident site. Given the circumstances, it is understandable that the train driver may not have adequately provided the exact location information. However, it is difficult to understand that the train controller did not question the driver to obtain specific information that was necessary to direct emergency services to the site. It would appear that the train controller had no structured method of obtaining such information. It was fortuitous that the incident was reported by another person, apparently on the site, through ‘000’ and that there was no delay in the arrival of emergency services.

### **4.3.3 Train driver**

The train driver had little direct involvement in the incident and he was experienced both in the operation of this type of train and the route from Swan Hill to Melbourne. Approaching the crossing the train was operated within the rules and procedures relevant to the operation and it was operating to schedule. The train driver was aware of the situation around him as it related to his approach to this level crossing with road vehicles approaching from both the Swan Hill and Kerang directions. He stated that his main concern was with the vehicles approaching from Swan Hill and assumed that the truck involved in this incident had sufficient time to take the correct action and yield at the crossing. This is considered a normal reaction for a train driver as he would be well aware that road vehicles are required to give way to trains. At the last moment, when it became obvious to the train driver that the truck from the Kerang direction might not stop, he was aware that the truck would pass behind the locomotive and he concluded that it was possible that the truck might miss the train and so did not apply the train brake. In the circumstances this is considered a reasonable course of action on the part of the driver. Had the driver applied the emergency brake at this time any speed reduction achieved would have been minimal and not have significantly varied the outcome of this incident.

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## **4.4 Passenger car crashworthiness**

The high relative velocity between truck and train, the high vehicle masses and the nature of the override of the truck trailer tray into the weaker parts of the rail passenger car body side led this to be a severe incident with severe consequences.

### **4.4.1 Body structure**

The N Class passenger cars pre-date modern developments in crashworthiness design. However, the investigation found that with regard to body side structural strength, modern rolling-stock is likewise susceptible to side impact. The focus of design for collision is generally on the vehicle ends and accordingly vehicle body side above the carriage floor is typically the most vulnerable to external impact loads.

In this incident, the body side of passenger car BRN20 was ripped away by the overriding trailer tray of the truck. Due to the similar susceptibility of modern rolling-stock to impact of this nature, the performance of BRN20 is not likely to have been significantly different to more modern rolling-stock on the Victorian network.

Given this incident and other recent level crossing incidents at Trawalla and Lismore which also involved side impact on a train by heavy road vehicles, there is a growing case for a review of crashworthiness standards for side impact loading. However, it should be noted that these three incidents involved significant side impact forces on the trains involved and it might be impractical to build rail vehicles to withstand such impact.

With regard to the end loading of BN19, the investigation found that some differences existed between the N Class passenger cars and what might be considered typical modern rolling stock. The N Class passenger car has its resistance to intrusion concentrated in end posts either side of the gangway whereas contemporary rolling stock typically have greater strength in the carriage corners. In this incident the gangway end posts of BN19 were effective in preventing more significant intrusion of the passenger compartment, whereas the corner end posts provided little resistance. The structural response of a modern rail vehicle to the end impact experienced by BN19 would depend on its specific configuration and structural scantlings. Comparing the performance of BN19 with modern rolling stock would therefore be open to considerable conjecture and accordingly the investigation has not sought to predict the likely performance of other rolling stock to the loading on BN19.

### **4.4.2 Interior**

#### **Seating**

Many seats within BRN20 were ripped from their fitted positions either through direct impact from the truck trailer or indirectly by impact from the front of debris sweeping the car. This is not a typical loading scenario for seat design and it is unlikely that any other type of conventional passenger train seat would have been able to withstand the intrusion which occurred in this incident.

However, the investigation did identify some weaknesses in the seating design and fixing methods. There is a case to review N Class passenger car seating against current design criteria for modern rolling-stock.

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## **Window Glass**

In this incident a number of passengers received injuries from being struck by pieces of glass after several windows shattered during the collision. While the performance of the glass was consistent with the expectations of toughened glass, there is the potential to lessen glass related injury through the use of an alternate type of glass or the use of a coating to retain shattered fragments.

### **4.5 Level crossing signage and warning devices**

The investigation determined that there were minor variations between the current Australian Standard and the warning devices and signage provided at the crossing. However, it is considered that the nature of the variations were such that they would have been unlikely to have had any effect on a road user's ability to detect or interpret the signs or warning devices.

The level crossing flashing lights and bells activated slightly more than 25 seconds before the train entered the crossing which exceeds the minimum warning time of 20 seconds specified in the relevant Australian Standard.

As discussed earlier, the approach along the highway to the crossing is curved. There is a potential for curved approaches to level crossings to limit the visibility of the crossing, associated warnings devices and approaching trains to road users. The issue of warning signage for curved approaches is not addressed in the applicable Australian Standard.

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## **5. CONCLUSIONS**

### **5.1 Findings**

#### **Personnel**

1. All members of the train crew were qualified to operate in their various roles on the train from Swan Hill to Melbourne.
2. The train driver was familiar with the track between Swan Hill and Kerang.
3. The truck driver was licensed to drive the truck involved in the incident.
4. The truck driver was familiar with the route between Kerang and Swan Hill.
5. The truck driver had a good heavy vehicle driving record and was an experienced driver in the type of operations being conducted on the day of the incident.

#### **Rail vehicle and operations**

6. The train was serviceable prior to the incident.
7. No faults were found with the locomotive or rail cars that could have contributed to the incident.
8. The rail cars were not built to any side impact crashworthiness requirements. There are no side impact crashworthiness standards in Australia for rail vehicles.
9. The train control centre had difficulty in determining the location of the incident for about 25 minutes after the event. This did not affect the arrival of emergency services at the site.

#### **Truck and its operation**

10. The truck was reported to have been serviceable prior to the incident.
11. The truck was loaded within the required limits.
12. The truck departed its depot about 30 minutes later than normal.

#### **Infrastructure**

13. The rail at the level crossing was serviceable prior to the incident.
14. The level crossing flashing lights and audible warning device were serviceable prior to the incident.
15. The operation of flashing lights and audible device exceeded the minimum warning time required by the Australian Standard 1742.7 – 2007.



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16. The level crossing flashing light units were fitted with incandescent light globes.
  17. The flashing light units at the level crossing complied with industry standards.
  18. Some aspects of the level crossing warning signage and pavement markings did not comply with Australian Standard 1742.7 – 2007 but this was not considered to be a factor in the incident.
  19. Australian Standard 1742.7 – 2007 does not address approaches to level crossings where the roadway is curved.

## **5.2 Contributing factors**

For reasons not determined the truck driver did not respond in an adequate time and manner to the level crossing warning devices.

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## 6. SAFETY ACTIONS

### 6.1 Safety actions taken since the event

Prior to the level crossing being returned to service after this incident the incandescent light globes in the flashing light units were replaced with light emitting diodes (LEDs) and the mechanical warning bell was replaced with an electronic bell.

On 25 June 2007, the Premier of Victoria announced a package to improve safety at level crossings across the State.

The safety package included:

- The installation of 53 automated advance warning signs, 26 at level crossings on State Highways and 27 high road traffic volume sites. These units consist of flashing signs positioned about 250 metres prior to a level crossing to warn motorists when a train is approaching the crossing.
- The installation of rumble strips at 200 level crossings to alert motorists that to upcoming level crossing signage.
- The updating of the Don't risk it! advertising campaign which is to be distributed via print, radio and television media and in school programs.
- An accelerated works program at about 75 level crossings to eliminate 'line of sight' problems.
- A variation of penalties for level crossing infringements and a trial of level crossing compliance cameras at two major level crossings.

The Victorian Level Crossing Steering Committee has commissioned a project to review the effectiveness of the improvements to active and passive level crossing to be implemented as a result of the announcement by the State Government.

On 25 October 2007 the level crossing involved in this incident was re-commissioned after the following improvements were made: the addition of boom barriers across the highway, the placement of rumble strips on the highway approaching the crossing, the installation of automated advanced warning signs, the fitting of updated warning signage, and the provision of a rail level crossing predictor to standardise warning times for approaching trains.

### 6.2 Recommended safety actions

#### V/Line Passenger Pty Ltd

##### **Safety issue**

The location of passenger trains on the Victorian non-urban network is not directly monitored by train control (Control). Following a rail incident, immediate advice to train control is required to be made by the train drivers. There is potential for this advice to be delayed because of driver incapacitation or radio malfunctions.

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### **RSA 2007005**

That V/Line Passenger Pty Ltd reviews the method by which the location of trains is determined with a view to implementing a system that allows 'real time' location of all trains.

#### **Safety issue**

During the emergency call from the train driver to Control, train controllers did not determine the location of the incident.

### **RSA 2007006**

That V/Line Passenger Pty Ltd reviews procedures to improve radio protocols and in particular provide a more robust system of obtaining information from train crews in the event of an onboard emergency.

#### **Safety issue**

Approaching the whistle board the train horn was sounded for a duration of less than half of a second. The length of horn blast at a whistle board is not specified in the Victorian Book of Rules. Horn blasts of such short duration do not provide an adequate warning to motorists or pedestrians of an approaching train.

### **RSA 2007007**

That V/Line Passenger Pty Ltd reviews the use of train horns and prescribes a minimum duration for the horn to be sounded at whistle boards.

#### **Safety issue**

Following the incident the train driver and conductors commented that the first aid kits were not adequately equipped to deal with some injuries. Also, the train driver was not issued with keys to allow him to un-stow the egress ladder.

### **RSA 2007008**

That V/Line Passenger Pty Ltd reviews onboard emergency equipment provided to train drivers and conductors to ensure that they are adequately able to deal with foreseeable incidents on trains. That drivers and conductors be trained in the use of any new equipment provided.

#### **Safety Issue**

Locomotives operated by some other Australian rail operators are configured so that the ditch lights flash when the locomotive warning horn is activated. This has the potential to make the locomotive more conspicuous to vehicle drivers and pedestrians in the vicinity of some level crossings.

### **RSA 2007009**

That V/Line Passenger Pty Ltd considers configuring locomotives they operate so that ditch lights flash when the locomotive warning horn is sounded.

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### **Safety Issue**

The N class passenger car seating design predates modern crashworthiness standards.

### **RSA 2007010**

That V/Line Passenger Pty Ltd reviews the seating used in N Class passenger cars against contemporary industry crashworthiness standards.

### **Safety Issue**

A number of passengers suffered glass related injuries.

### **RSA 2007011**

That V/Line Passenger Pty Ltd considers alternatives treatments which have the potential to reduce glass related injury.

### **VicRoads**

### **Safety Issue**

The maximum vehicle speed over the level crossing on the Murray Valley Highway was 100 km/h. At this speed the time for motorists to react and make a decision on the correct action to take at a level crossing is limited.

### **RSA 2007012**

That VicRoads reviews road vehicle speeds approaching level crossings with a view to limiting vehicle speeds to provide additional decision time for motorists.

### **Safety Issue**

Unlike the operators of other commercial transport modes, the drivers of heavy road vehicles are not required to be reassessed at regular intervals throughout their driving careers.

### **RSA 2007013**

That VicRoads considers the regular reassessment and education of heavy road vehicle drivers with a view to maintaining their standard of operations and knowledge of their driving environment.

### **The Department of Infrastructure**

### **Safety Issue**

Passenger cars are typically not designed to withstand side impact by road vehicles.

### **RSA 2007014**

That the department reviews the adequacy of current crashworthiness standards applied to passenger-carrying rolling-stock in Victoria with particular focus on side impact loading.





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